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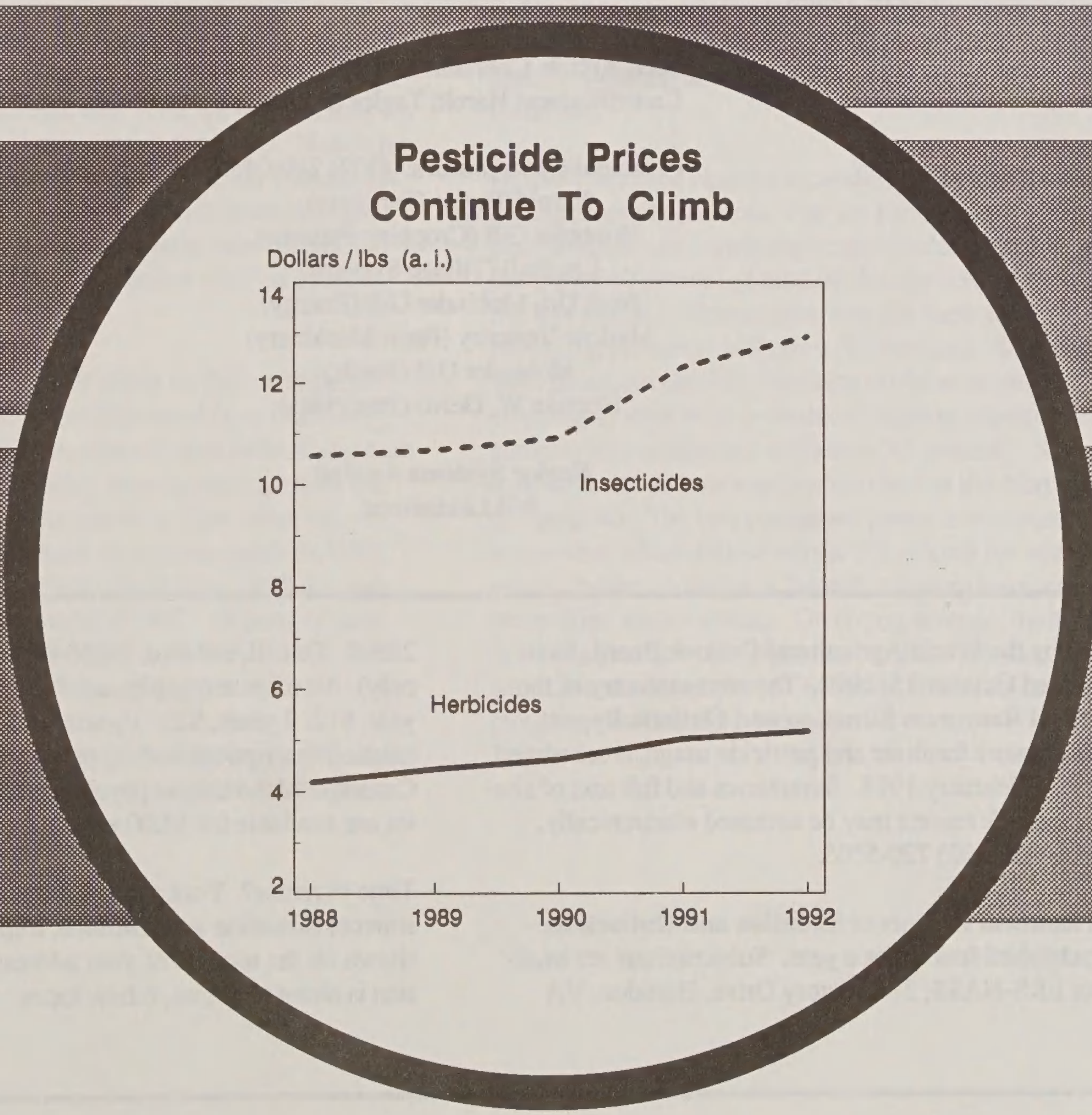

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Summary

U.S. fertilizer supplies during 1992/1993 are expected to be available at stable or slightly higher prices than in 1991/1992. Planted acreage of the major fertilizer-using crops will be the main factor determining 1992/1993 usage while fertilizer production costs, available supplies, and world demand will influence prices. Worldwide fertilizer production and consumption are anticipated to decline again next year in response to political and economic events in Eastern Europe, the former USSR, and the Middle East. U.S. plant nutrient use is estimated to have increased to 20.9 million tons during the 1991/92 fertilizer year, up 2.8 percent from the 20.3 million tons used a year earlier.

U.S. farmers can expect 1993 energy prices to remain at or slightly above 1992 averages due to steady or slightly higher prices likely for imported crude oil. For 1991, direct farm energy expenditures were approximately 3 percent below those in the preceding year. This is attributed to higher energy prices coupled with a slight reduction in energy use due to fewer acres planted.

Conservation tillage systems were used on about 21 percent of the 1992 harvested winter wheat acreage compared to 16 percent in 1991. This increase was in mulch-till, up from 13 to 18 percent, while no-till remained at 3 percent. Nearly 68 percent of the acreage was conventionally tilled without the moldboard plow, reflecting chisel plow use in the normal wheat-fallow rotations of the arid western states. Over 90 percent of the 1991 fall potato production utilized conventional tillage methods.

The economic slowdown and its affect on farmer expectations have been major factors in decreased farm machinery investment in 1992. However, some economic indicators are encouraging. Current machinery interest rates are near the low of the early 1960's. Farm non-real estate asset values were up in 1991 and are forecast to increase again in 1992. Crop receipts held steady at $80 billion from 1990 through 1991, but are forecast to increase in 1992. Exports of farm machinery increased during the first 7 months of 1992 over the same period last year and imports decreased.

For the 1991/1992 crop year, seed consumption for the eight major crops was 6 million tons, up 1 percent from the previous year. This resulted from gains in wheat, corn, rice, and sorghum planted acreage. Higher corn, grain sorghum, small grains, and cotton seed prices in 1992 were offset by much lower seed potato, soybeans, and several forage seed prices. As a result, the April 1992 prices-paid index for all seeds was 1 point lower than last year. Farm seed expenditures were up in 1991 and are expected to be higher in 1992 because of planted acreage increases. The 1991 net seed trade surplus rose 15 percent over 1990, to $507 million. The increase primarily reflected gains in corn, vegetable, and flower seed exports.

Total 1992 pesticide use on the 10 major field crops is projected at 487 million pounds active ingredient, up 9 million pounds from 1991. The total area planted to crops increased, although there were some decreases in acreage planted to cotton, barley, and oats. Average farm-level herbicide prices rose 2.4 percent and insecticide prices rose 4.8 percent. Pesticide manufacturers' costs have increased because of the need to develop additional data to reregister older products, and to research and develop new products. Many manufacturers have also embarked on expensive biotechnology research. Dealers' costs have also risen, especially for liability insurance.

Agroclimatic and economic conditions are key factors influencing cropping patterns. For the survey years 1989-1991, a corn-soybean-corn cropping sequence dominated in the Corn Belt, with 40 percent of land producing corn in 1991 following this pattern. Monoculture was the most common corn producing pattern in Nebraska (55 percent). Two patterns were prevalent on 1991 Southern soybean acreage, a double-cropping system with soybeans following winter wheat (30 percent) and continuous soybeans (33 percent). A soybean-corn-soybean pattern was predominant in the Northern states (59 percent). The two prominent patterns in wheat growing states were wheat-fallow-wheat (23 percent for winter wheat), where moisture is limited, and continuous wheat (34 percent for winter wheat). On cotton acreage, monoculture is widely practiced (61 percent). In the major rice producing states, alternating soybeans with rice is the most common cropping practice (35 percent).

Recent political and economic changes in Eastern Europe, the former USSR, and the Middle East will likely reduce the growth in world fertilizer production and consumption. The disintegration of their command economies and slow evolution toward open markets has created a hard currency shortage and fertilizer production and distribution problems for former USSR and Eastern Europe countries. Ammonia plants in Kuwait and Iraq, damaged during the Gulf War, are not likely to be repaired in the near future; nor will new plant construction be completed on schedule.

Fertilizer prices are no longer subsidized in Eastern Europe and the former USSR. Farmers are not willing to spend limited monies on fertilizers when relative prices of agricultural products are down sharply. As a result, fertilizer consumption in these areas is down. The closure of non-economic plants and reduced investment in new plants could result from this reduced demand.

Fertilizer supplies in the United States during 1993 are expected to be ample at stable or slightly higher prices (near 1991 levels). However, planted acreage of the major fertilizer-using crops will be the main factor determining 1993 usage. Available fertilizer supplies, world demand, petroleum (especially natural gas), and sulphur prices, are significant influences on fertilizer prices.

The secretary of agriculture announced a 0 percent set-aside for wheat which was finalized July 31, 1992. He has preliminarily announced that the set-aside for corn will be 10 percent, up 5 percent from last year. Grain sorghum has been set at 5 percent and barley and oats at 0 percent. These preliminary set-aside numbers will not be finalized until November 15, 1992. If these numbers become final, they could have a dampening effect on fertilizer and other input use in 1993.

Table 1--Planted crop acreage, U.S.

Crop	1991	1992	Change
	Million acres		Percent
Wheat	69.9	72.3	3
Feed grains	104.6	107.5	3
Corn	76.0	79.3	4
Other 1/	28.6	28.2	-2
Soybeans	59.1	59.0	-0
Cotton	14.1	13.6	-3
Rice	2.9	3.0	6

1/ Sorghum, barley, and oats.

Consumption

U.S. plant nutrient use is estimated to have increased to 20.9 million tons during the 1991/92 fertilizer year (July 1-June 30), up 2.8 percent from the 20.3 million tons a year earlier. Most of the increase was due to more corn planting. Corn acreage, which accounted for an estimated 44 percent of plant nutrient use in 1990/91, rose 4.5 percent; wheat acreage, 14 percent of nutrient use, increased by 3 percent (table 1).

Table 2--Fertilizer use on winter wheat, 1992 1/

State	Acres 2/	Fields in survey	Acres receiving: Any fertilizer	Acres receiving: N	Acres receiving: P205	Acres receiving: K20	Application rates: N	Application rates: P205	Application rates: K20	Proportion fertilized: At or before seeding	Proportion fertilized: After seeding	Proportion fertilized: Both
	Thousand	No.	Percent				Pounds per acre			Percent		
Arkansas	900	67	100	100	31	28	101	45	54	1	66	33
Colorado	2,300	90	63	63	15	5	39	16 *	5 **	79	10	11
Idaho	800	92	91	91	50	6	93	35 *	31 *	37	29	34
Illinois	1,100	72	98	98	83	5	86	69	48 **	8	17	75
Indiana	450	62	98	98	81	69	88	60	62	17	16	67
Kansas	10,901	253	87	87	48	7	58	33	29 *	65	7	28
Missouri	1,350	71	96	96	77	77	77	47	52	28	28	44
Montana	2,250	96	81	81	74	16	35	25	9 *	82	4	15
Nebraska	1,950	99	77	77	35	6	47	28	8 **	69	13	17
Ohio	1,140	67	100	100	91	85	89	64	66	15	15	70
Oklahoma	6,000	161	95	94	45	7	73	32	14 **	48	10	42
Oregon	850	96	97	97	15	7	63	35 *	25 *	74	11	15
South Dakota	1,200	56	45	45	35	2	35 *	28	13	65	22	13
Texas	3,799	173	69	69	30	6	77	41	14 **	69	11	20
Washington	2,000	137	97	97	37	5	75	29 *	21 **	83	1	15
Area:												
1992	36,990	1,592	85	85	46	13	66	37	40	57	12	31
1991	34,180	1,655	84	84	49	19	65	40	54	58	12	30

= Insufficient data. nr = None reported. * = CV greater than 10 percent. ** = CV greater than 20 percent.

1/ Preliminary. 2/ Acres harvested for winter wheat.

The April 1992 index of prices paid by farmers for all fertilizers was 3 percent less than spring 1991. Increased domestic supplies and reduced world consumption resulted in lower fertilizer prices.

Fertilizer Use on Winter Wheat

Fertilizer was applied to 85 percent of the winter wheat acres harvested in 1992 (table 2), about equal to the previous year. The proportion of winter wheat acres treated with nitrogen and phosphate remained about the same at 85 and 46 percent, while acres treated with potash decreased to 13 percent. Nitrogen per-acre application rate increased from 65 to 66 pounds. The application rate for phosphate and potash decreased from 40 and 54 pounds to 37 and 40. Idaho acreage received the most nitrogen per acre at 93 pounds, while Illinois and Ohio had the highest application rates for phosphate and potash at 69 and 66 pounds per acre, respectively. The least amount of nitrogen per acre (35 pounds) was applied in Montana and South Dakota.

Fertilizer Use on 1991 Fall Potatoes

Some fertilizer was applied to 99 percent of the acreage planted to fall potatoes in 1991; the proportion of acres treated ranged from 99 percent for nitrogen to 88 percent for potash (table 3). The area average for nitrogen was 195 pounds per acre, while that for phosphate was 158 pounds, and 143 pounds for potash.

Application rates for the three nutrients varied significantly by state. Similar to last year, North Dakota acreage received the least amount of nitrogen and phosphate, and Colorado acreage had the least amount of potash. Washington received the highest per acre applications of nitrogen and phosphate and Wisconsin the most potash.

Use of Manure, Lime, Sulfur, and Micronutrients in 1991

Manure was applied to 19 percent (17 percent in 1990) of all corn acres surveyed in 1991 (table 4). Use ranged from 43 percent (same as in 1990) of corn acres in Wisconsin to 7 percent in Missouri. Manure use on other crop acreage surveyed was less common, ranging from 5 percent for soybeans to 2 percent for peanuts and rice. Micronutrient use also varied considerably by crop; over half of the potato acres planted received micronutrients in 1991, while only 1 percent of wheat acres were treated.

Lime is applied to balance a soil's pH (a measure of its acidity or alkalinity), which increases the yield potential of crops by improving the availability of soil nutrients. The fre-

Table 4--Manure, lime, sulfur, and micronutrient use on selected crops, 1991

Crop	Acres 1/	Acres receiving: Manure	Lime	Sulfur	Other 2/	Application per acre: Lime	Sulfur
	1,000	--------Percent--------				Tons	Lbs
Corn	68,530	19	4	10	11	1.7	11
Cotton	10,860	3	2	20	18	1.0	12
Peanuts	1,446	2	48	NR	29	0.8	NR
Potatoes	1,116	4	4	52	56	0.9	59
Rice	1,880	2	2	NR	11	NR	15
Sorghum	8,050	4	1	6	5	2.4	15
Soybeans	49,650	5	5	1	2	1.7	12
Wheat:							
All	50,680	4	1	7	1	1.4	11
Durum	3,000	4	NR	2	1	NR	5
Spring	13,500	3	NR	2	1	NR	5
Winter	34,180	3	2	10	2	1.4	12

NR = None reported. * = Less than 0.5 percent.

1/ Includes the major producing States for each crop. Information is based on harvested acres for winter wheat and planted acres for all other crops. 2/ Other includes micronutrients like boron, calcium, copper, iron, magnesium, manganese, molybdenum, and zinc.

Table 3--Fertilizer use on fall potatoes, 1991

State	Acres planted 1/	Fields in survey	Acres receiving: Any fertilizer-	N	P2O5	K2O	Application rates: N	P2O5	K2O	Proportion fertilized: At or before seeding	After seeding	Both
	1,000	No.	---------Percent--------				--Pounds per acre--			--------Percent------		
Colorado	71	66	98	99	99	86	194	178	74	9	2	89
Idaho	395	306	100	100	98	81	226	175	94	18	3	79
Maine	81	162	100	100	100	100	165	177	177	90	0	10
Michigan	35	105	100	100	100	100	147	146	227	20	0	80
Minnesota	70	127	100	100	98	81	91	77	152 *	56	0	44
New York	2/ 23	61	99	100	93	97	112	161	156	72	4	24
North Dakota	155	101	96	96	96	83	97	89	102 *	71	0	29
Oregon	53	125	93	92	91	79	227	142	113	25	7	67
Pennsylvania	21	89	100	100	95	95	158	136	169	60	6	35
Washington	144	146	100	100	99	97	279	225	213	29	10	60
Wisconsin	68	108	100	100	97	100	253	136	358	11	1	88
Area:												
1991	1,116	1,396	99	99	98	88	195	158	143	37	3	60
1990	1,087	1,157	99	98	98	89	198	163	143	41	4	54

* = CV greater than 10 percent.

1/ Preliminary. 2/ Does not include Long Island.

quency of lime applications can range from every year on highly acidic soils to every 5-10 years on the less acidic soils in the Midwest. Lime was applied to 48 percent of the peanut and 4 percent of the corn acres surveyed in 1991, but no lime was reported used on durum or spring wheat. Lime application rates ranged from 2.4 tons per acre for sorghum to 0.8 tons for peanuts.

Like other essential nutrients, sulfur plays an important role in plant growth. Plants low in sulfur are often small and spindly, and sulfur deficiency can cause reduced root nodulation in legumes. Sulfur use was more common than lime on all crops surveyed except soybeans. Sulfur use was most prevalent on fall potatoes; calcium sulfate is frequently applied to extend potato storage life. Of the potato acres surveyed, 56 percent received an average of 59 pounds of sulfur per acre in 1991.

Regulatory Action

The Environmental Protection Agency (EPA) June 1992 ruling on phosphoric acid production wastes requires the disposal of phosphogypsum in stacks or mines, except for agricultural usage. Farmers are permitted to use it as a soil amendment as long as its radon content is within acceptable levels. Research use is limited to 700 pounds or less per project.

Table 5--U.S. fertilizer supplies 1/

Item	1990/91	1991/92	Change
	Million short tons		Percent
July 1 inventory:			
Nitrogen	1.14	1.01	-11
Phosphate 2/	.52	.57	10
Potash	.34	.19	-44
Production:			
Nitrogen	14.01	14.49	3
Phosphate 2/	12.06	12.43	3
Potash	1.83	1.92	5
Imports:			
Nitrogen	3/ 3.42	3/ 3.59	5
Phosphate 2/	.05	.07	40
Potash	4.61	5.24	14
Exports:			
Nitrogen	3/ 3.37	3/ 3.42	2
Phosphate 2/	5.57	6.58	18
Potash	.63	.66	5
Domestic supply: 4/			
Nitrogen	3/ 15.20	3/ 15.67	3
Phosphate 2/	7.06	6.49	-8
Potash	6.15	6.69	9

1/ Data for July through June for the fertilizer year starting July 1. 2/ Does not include phosphate rock. 3/ Does not include imports of anhydrous ammonia from the former USSR. Thus, nitrogen imports and domestic supply are significantly understated. Also, aqua ammonia imports include only January-June 1990 data. 4/ Includes requirements for industrial uses.

Futures Market

The Chicago Board of Trade (CBOT) started diammonium phosphate (DAP)--18-46-0 futures on October 18, 1991. The contracts includes lots of 100 short tons for delivery in Central Florida in March, June, September, and December. Effective September 11, 1992, the CBOT started anhydrous ammonia (82-0-0) futures. It is also traded in 100 ton units with contract months being March, June, September, and December. Anhydrous ammonia price basis is FOB Louisiana pipeline, barge, or railcar.

Supplies

Effective January 1990, the U.S. Department of Commerce (DOC) reinstated the reporting of anhydrous ammonia quantity data for all countries except imports from the former USSR. Since imports from the former USSR represent a large portion of U.S. imports, nitrogen imports and domestic supply are significantly understated in this report.

Domestic supplies of nitrogen and potash in 1991/92 increased from a year earlier while phosphate supplies went down. Supplies increased for nitrogen and potash because of expanded domestic production and increased imports (table 5). Domestic supplies of phosphate decreased due to increased exports of phosphate materials.

Trade

U.S. nitrogen, phosphate, and potash exports (nutrient content) during July 1991-June 1992 increased 2, 18, and 4 percent, respectively from last year's level. Urea exports to China increased 28 percent while diammonium phosphate (DAP) exports to India and China went up 33 and 23 percent. Exports of monoammonium phosphate (MAP) to Canada and potash to Brazil increased 32 and 17 percent, respectively.

The volume of fertilizer materials exported from the United States varied when compared with year-earlier levels. For July 1991-June 1992, DAP exports climbed 12 percent from 9.5 to 10.7 million tons while monoammonium phosphate exports went up 49 percent from 749,000 to 1.1 million tons. Phosphate rock exports continued declining to 5.6 million tons, a 16 percent decrease. The phosphate rock of other exporting countries has a higher ore content than that of the United States.

Nitrogen solution exports decreased 12 percent from 447,000 tons in 1990/91 to 395,000 in 1991/92. Urea exports increased 11 percent from 1.0 to 1.2 million tons, and concentrated superphosphate exports increased 52 percent from 752,000 to 1.1 million tons. Exports of ammonium nitrate and potassium sulfate went up 104 and 24 percent, while am-

monium sulfate and potassium chloride decreased 12 and 2 percent, respectively.

The main fertilizer deficit areas will continue to be in Asia, particularly China and India. In addition, France, Belgium, Italy, Japan, Pakistan, Korea, Mexico, and Brazil continue to be major recipients of U.S. fertilizer. During July 1991-June 1992, over 53 percent of urea exports and 49 percent of diammonium phosphate exports-- representing 626,000 and 5.2 million tons of product, respectively-- went to China. Fertilizer consumption in China has grown rapidly during the past few years. Exports to China will increase steadily because of the delayed increase in domestic production, but prices are expected to be higher unless subsidized by the government. India received another 18 percent of DAP exports, while Canada and Chile obtained another 17 and 11 percent of urea, respectively.

Belgium-Luxembourg and France remain important buyers of U.S. nitrogen solutions, receiving 51,000 and 335,000 tons (98 percent) of these exports during 1991/92. Brazil and Guatemala received 361,000 and 97,00 tons or 41 and 11 percent of ammonium sulfate exports, respectively. Brazil also received 357,000 tons or 45 percent of potassium muriate exports. Bangladesh, Brazil and Chile received 232,000, 218,000 and 200,000 tons or 20, 19, and 17 percent of concentrated superphosphate exports. Phosphate rock exports have declined as a result of increased competition from Morocco. However, Mexico, South Korea, Canada, Japan, the Netherlands, France, and India remained the major recipients.

Fertilizer material imports for many products were greater than year-earlier levels. Potassium chloride imports during July-June were up 14 percent from a year earlier to 8.4 million tons. Imports of potassium chloride from Canada remained strong at around 94 percent of the total, and those from Israel decreased to 2 percent at 165,000 tons. Ammonium nitrate imports were up 8 percent from 408,000 to 505,000 tons, and ammonium sulfate imports climbed 19 percent to 378,000 tons. Anhydrous ammonia imports were up 13 percent. However, urea imports decreased 15 percent from 2.0 to 1.7 million tons, with Canada responsible for exporting 78 percent of the total.

Production

Domestic nitrogen, phosphate, and potash fertilizer production increased during 1991/92 in response to increased domestic planted acres and reduced world production. The slow evolution of the former USSR and Eastern Europe toward a market economy has caused tighter world supplies. In response, U.S. nitrogen production increased 3 percent during July 1991-June 1992. Some anhydrous ammonia producers operated at close to capacity. Phosphate production increased 3 percent and U.S. potash production 5 percent from year earlier levels.

Table 6--April farm fertilizer prices 1/

Year	Anhydrous ammonia (82%)	Phosphates: triple super- (44-46%)	Phosphates: diammonium (DAP) (18-46-0%)	Potash (60%)	Mixed (6-24-24%)	Prices paid index 1977=100
	Dollars per short ton					
1987	187	194	220	115	176	117
1988	208	222	251	157	208	132
1989	224	229	256	163	217	141
1990	199	201	219	155	198	130
1991	210	217	235	156	206	136
1992	208	206	224	150	200	132

1/ Derived from the April survey of farm supply dealers conducted by NASS, USDA.

Prices

Aggregate farm fertilizer prices in spring 1992 were 3 percent less than a year earlier (table 6). Reduced world demand as a direct result of the economic reforms in Eastern Europe and the former USSR and increased U.S. production pushed prices down. In addition, planted U.S. acres in 1992 did not increase as much as anticipated by the fertilizer industry resulting in excess domestic supplies and lower fertilizer prices.

Nitrogen prices generally have changed less than phosphate or potash prices since spring 1991, with urea and anhydrous ammonia prices dropping 7 and 1 percent, respectively. Prices of other nitrogen materials either remained constant or changed slightly. Triple superphosphate and diammonium phosphate prices went down 5 percent each. Potash prices also decreased slightly; the price of potassium chloride went from $156 to $150 per ton in April.

Prices paid by farmers for fertilizer products reflect wholesale trends as well as other economic relationships. Since spring 1992, fertilizer wholesale prices have dropped in response to excess domestic supplies and reduced demand. This seasonal down-turn in prices will likely reverse direction later this fall, as dealers increase stocks in anticipation of demand next year. Fall retail prices are typically less than the following spring prices. Spring 1993 prices will likely be higher than fall 1992 prices and will reflect expectations for 1993 planted acreage of fertilizer intensive crops such as corn, and fertilizer production costs.

Cropping Patterns

Crop rotations, due to their presumed economic and environmental benefits, are receiving increased scrutiny from physical scientists, economists, and public policy decision-makers. The benefits often associated with increased cropping diversity on specific fields include: increased nitrogen content of soil through legumes; better soil moisture management; control of insects, weeds, and diseases; reduced soil

erosion; use of residual nitrogen; and abatement of water pollution often associated with runoff and leaching. Most acreage in the U.S. is planted to a variety of crops over time, while other cropland is in monoculture production pattern. While changes in relative crop profitability from year to year can affect cropping patterns, agricultural policies and government programs are also influential. Examples of such agricultural policies are: set aside levels, planting flexibility provisions, and conservation compliance regulations. In general, however, cropping patterns on land producing the major field crops have remained stable over the last several years (1,2).

Corn

The two most common cropping sequences in the 10 major corn production states surveyed were: Corn-soybean-corn and continuous corn. These two cropping patterns were used on 64 percent of the 1991 corn producing acreage (table 7).

Continuous corn production was used on about one-fourth of the 1991 corn acreage. This pattern was most common in Nebraska where 55 percent of the corn land was monocultured. Continuous cropping was practiced on 75 percent of the irrigated corn land. This lack of diversity could be due to fixed investment in irrigation capital and heavy participation in government commodity programs. Continuous corn production was also common in Wisconsin (39 percent), Michigan (28 percent), Iowa (25 percent), and Indiana (21 percent). In addition to continuous corn production, crops such as sugarbeets, dry beans, corn silage, and vegetables are also used in rotation with corn in Michigan.

A corn-soybean-corn pattern dominated in Illinois (58 percent), Iowa (56 percent), Minnesota (49 percent), Indiana (45 percent), Missouri (35 percent), South Dakota (32 percent), and Ohio (30 percent). An estimated 40 percent of the 1991 surveyed corn land grew soybeans in 1990 and corn in 1989. The ability of soybeans to fix nitrogen in the soil can allow farmers to reduce commercial nitrogen applications on the succeeding crop. Pests, such as corn rootworm, can also be controlled by rotating to other crops, such as legumes and small grains.

In the dairy state of Wisconsin, alfalfa is often grown prior to corn production. In 1991, 12 percent of the corn growing land grew alfalfa in the previous 2 years. South Dakota, on the other hand, grew a variety of crops other than soybean, corn, and wheat such as corn for silage, sorghum for silage, and millet. Overall, the corn cropping pattern remained fairly stable between 1990 and 1991.

Soybeans

The two most common cropping patterns reported in the 14 major soybean producing states were: soybean-corn-soybean and continuous soybean production. Farmers in the Northern States mostly followed a soybean-corn-soybean sequence whereas, in the Southern States continuous soybean production was most common (table 8).

Table 7--Cropping patterns used on land producing corn, 1991

Previous crop								Nebraska						area
1990	1989	IL	IN	IA	MI	MN	MO	State	Dry	Irr.	OH	SD	WI	1991
		Million acres planted												
		11.2	5.70	12.50	2.60	6.60	2.30	8.20	2.70	5.50	3.70	3.80	3.80	60.40
		Percent												
Corn	Corn	16	21	25	28	13	11	55	14	75	10	10	39	24
Corn	Soybean	11	11	7	6	7	9	6	12	3	6	2	2	7
Corn	Alfalfa	1	*	2	5	3	nr	*	nr	*	2	2	13	2
Corn	Other	*	1	2	11	4	3	4	4	2	7	3	6	3
Soybean	Corn	58	45	56	12	49	35	18	36	9	30	32	7	40
Soybean	Soybean	5	7	2	5	4	18	2	3	1	11	3	1	4
Soybean	Other	2	3	1	3	6	3	nr	1	nr	7	3	2	2
Fallow 1/	Other	2	8	1	13	1	13	5	14	1	18	5	9	5
Alfalfa	Alfalfa	1	2	3	2	3	1	nr	nr	nr	1	nr	12	2
Alfalfa	Other	1	1	*	nr	*	2	nr	nr	nr	1	nr	1	1
Wheat	Other	nr	nr	nr	3	5	nr	nr	nr	nr	1	15	nr	2
Oats	Corn	1	nr	1	nr	1	nr	2	4	nr	1	10	*	1
Oats	Other	nr	nr	nr	nr	1	*	nr	nr	nr	*	3	*	*
Sub-total		98	99	100	88	97	95	92	88	91	95	88	92	95
Other	Other	2	1	0	12	3	5	8	4	9	5	12	8	5
	Total	100	100	100	100	100	100	100	100	100	100	100	100	100

nr = None reported. * = less than 1 percent. 1/ No crops planted.

Table 8--Cropping patterns used in northern soybean production, 1991

Category				IL	IN	IA	MN	MO	NE	OH	1991 Area
Planted acres (1,000)				9,200	4,450	8,800	5,500	4,500	2,500	3,900	38,850
1990		1989									
Fall	Spring/ Summer	Fall	Spring/ Summer	% of acres							
--	Soybean	--	Corn	3	5	5	5	8	3	9	5
--	Soybean	--	Soybean	2	2	1	1	17	2	9	4
--	Soybean	--	Other	2	1	*	2	4	2	4	2
--	Corn	--	Corn	10	18	9	8	3	16	8	10
--	Corn	--	Soybean	68	55	78	58	27	55	37	59
--	Corn	--	Fallow 2/	2	1	1	nr	2	*	11	2
--	Corn	--	Other	2	6	3	7	2	3	6	4
--	Fallow	--	Other	3	4	*	1	7	3	7	3
--	Other	--	Other	1	3	1	17	10	14	4	6
--	Soybean	WW 3/	Other	1	nr	nr	nr	5	nr	2	1
WW	Other	--	Other	5	5	*	*	9	*	*	4
WW	Other	WW	Other	1	1	nr	nr	5	nr	nr	1
			Total 1/	100	100	100	100	100	100	100	100

nr = None reported. * = Less than 1 percent.

1/ May not add to 100 due to rounding. 2/ No crops planted. 3/ Winter Wheat.

Table 9--Cropping patterns used in southern soybean production, 1991

Category				AR	GA	KY	LA	MS	NC	TN	1991 Area
Planted acres (1,000) 1/				3,200	650	1,150	1,450	1,900	1,350	1,100	10,800
1990		1989									
Fall	Spring/ Summer	Fall	Spring/ Summer	% of acres							
--	Soybean	--	Corn	nr	2	7	1	2	2	2	1
--	Soybean	--	Soybean	27	22	6	56	57	14	39	33
--	Soybean	--	Rice	5	nr	nr	3	5	nr	nr	3
--	Soybean	--	Other	2	3	2	7	3	3	5	4
--	Corn	--	Corn	nr	1	6	1	nr	1	6	2
--	Corn	--	Soybean	nr	7	26	1	3	24	4	7
--	Corn	--	Other	1	2	nr	nr	nr	7	nr	1
--	Fallow	--	Other	2	nr	2	7	6	4	1	3
--	Rice	--	Soybean	16	nr	nr	4	4	nr	nr	6
--	Rice	--	Other	5	nr	nr	5	1	nr	nr	2
--	Other	--	Other	4	1	3	7	6	3	5	4
--	Soybean	WW 3/	Soybean	4	3	3	1	4	1	5	3
--	Soybean	WW	Other	1	nr	3	nr	nr	2	2	1
WW	Corn	--	Soybean	nr	2	12	nr	nr	6	3	3
WW	Corn	--	Other	nr	13	4	nr	nr	3	2	2
WW	Soybean	--	Soybean	4	5	nr	nr	1	2	5	2
WW	Soybean	--	Other	2	4	4	nr	nr	1	3	2
WW	Fallow	--	Other	2	3	nr	1	2	2	2	2
WW	Soybean	WW	Soybean	21	10	10	6	7	8	14	12
WW	Soybean	WW	Other	nr	2	1	nr	1	nr	1	1
WW	Other	--	Other	5	18	13	0	0	17	3	6
			Total 1/	100	100	100	100	100	100	100	100

nr = None reported. * = Less than 1 percent.

1/ May not add to 100 due to rounding. 2/ No crops planted. 3/ Winter Wheat.

States where the soybean-corn-soybean pattern was most popular were: Iowa, 78 percent; Illinois, 68 percent; Minnesota, 58 percent; Indiana and Nebraska 55, percent. In these States, 59 percent of 1991 soybean producing acres used this practice. This pattern was popular because, in addition to competing economically with other crops, soybeans provide a natural source of nitrogen for succeeding crops.

Continuous soybean production was practiced on over one-third of the 1991 soybean acreage. Soybean monoculture appears to be preferred in Southern States such as Arkansas, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, and Tennessee (table 9). In the Delta States - Arkansas, Louisiana, and Mississippi - rice was rotated with soybeans on 9 percent of 1991 soybean land.

In the 1989-1991 period, a continuous double-cropping system, with soybeans following winter wheat was reported extensively in the Southern States. Arkansas reported the largest proportion of these acres, at 21 percent. In Georgia, in addition to growing soybeans continuously, it was also common to alternate soybeans with peanuts and corn.

Cotton

Continuous cotton is widely practiced in the 6 major cotton producing states. Of the 1991 cotton land, 61 percent grew cotton in the previous 2 years (table 10).

Continuous cotton was very common in Louisiana (82 percent), Arizona (80 percent), Mississippi (77 percent), Arkansas (73 percent), Texas (55 percent), and California (48 percent). The reason that monocultured cotton remains the preferred practice in these States may be attributed to the economic attractiveness of government commodity programs.

Sorghum is often rotated with cotton in Texas, while vegetables are rotated in California. Other crops such as alfalfa, barley, and winter wheat are also rotated with cotton in California. Another practice common to both states is to idle cotton land for 1 or 2 years before planting cotton. Soybeans are rotated with cotton mostly in Arkansas and Louisiana.

Rice

The most common cropping practices prevalent in Arkansas and Louisiana, the major rice producing states, are soybean-soybean-rice and rice-soybean-rice. These two patterns were practiced on 62 percent of 1991 rice acreage (table 11). Of the 1991 rice acres, 16 percent were planted to rice in 1990 and either fallowed or planted to soybeans or rice in 1989.

In Arkansas, 72 percent of 1991 rice acres grew soybeans in the previous year, while the share was 53 percent in Louisiana. A rice-fallow-rice pattern is more common in Louisiana where 24 percent of 1991 rice acres were fallowed in the previous year.

Table 10--Cropping patterns used on land producing cotton, 1991

Previous crop 1990	1989	AZ	AR	CA	LA	MS	TX	1991 area
		Million acres planted						
		0.36	1.00	0.98	0.88	1.25	6.40	10.87
		Percent						
Corn	Cotton	nr	nr	2	2	nr	3	2
Corn	Other	nr	nr	nr	1	nr	3	1
Sorghum	Cotton	nr	nr	nr	nr	nr	9	5
Sorghum	Other	nr	1	nr	nr	nr	3	2
Soybean	Soybean	nr	16	nr	7	2	1	3
Soybean	Other	nr	1	nr	nr	4	*	1
Fallow 1/	Fallow	1	1	6	nr	7	5	4
Fallow	Cotton	4	nr	6	nr	1	4	3
Fallow	Other	nr	nr	3	nr	nr	1	1
Cotton	Cotton	80	73	48	82	77	55	61
Cotton	Fallow	6	nr	3	nr	1	2	2
Cotton	Soybean	nr	6	nr	7	1	nr	1
Cotton	Other	3	1	7	1	1	8	6
Vegetable	Other	3	nr	8	nr	6	2	3
	Sub-total	97	99	83	100	100	96	95
Other	Other	3	1	17	0	0	4	5
	Total	100	100	100	100	100	100	100

nr = None reported. * = Less than 1 percent.

1/ No crops planted.

Table 11--Cropping patterns used on land producing rice, 1991

Previous crop 1990	1989	AR	LA	1991 area
		Millon acres planted		
		1.15	0.30	1.45
		Percent		
Sorghum	Soybean	1	nr	1
Sorghum	Rice	2	*	1
Soybean	Soybean	34	10	27
Soybean	Rice	34	39	35
Soybean	Fallow 1/	3	3	3
Soybean	Other	1	1	1
Fallow	Soybean	3	4	3
Fallow	Rice	1	10	4
Fallow	Fallow	3	10	5
Fallow	Other	nr	*	*
Rice	Sorghum	2	nr	1
Rice	Soybean	8	8	8
Rice	Fallow	*	4	1
Rice	Rice	6	9	7
Rice	Other	nr	*	*
	Sub-total	97	98	96
Other	Other	3	2	4
	Total	100	100	100

nr = None reported. * = Less than 1 percent.
1/ No crops planted.

Spring and Durum Wheat

Varied cropping patterns were practiced in spring wheat production, reflecting moisture availability in the major producing states. However, the two most common cropping practices were wheat-fallow-wheat, and continuous spring wheat. These two patterns were used on about 33 percent of the 1991 spring wheat acreage (table 12).

Montana reported 58 percent of its 1991 acres using a wheat-fallow-wheat production practice. For all surveyed states combined, 35 percent of the 1991 spring wheat crop was grown on land left idle in the preceding year. Continuous spring wheat production, the second most popular practice, was used on 12 percent of the 1991 spring wheat acreage.

Where rainfall was adequate or irrigation was permitted, more input-intensive crops were grown in the year preceding spring wheat production. In Minnesota, 22 percent of the spring wheat acres were planted to soybeans in the preceding year, while in South Dakota, corn preceded spring wheat on 20 percent of 1991 acreage.

Other crops in rotation with spring wheat were sugarbeets, sunflowers, dry beans, and potatoes. While sugarbeets were rotated with spring wheat in Minnesota, sunflowers were similarly rotated in North Dakota.

The major durum wheat producing state is North Dakota. About 40 percent of the acreage planted to durum wheat was left idle in the preceding year because of the moisture constraint faced by farmers.

Table 12--Cropping patterns used on land producing spring and durum wheat, 1991

Previous crop		Spring wheat					Durum wheat
1990	1989	MN	MT	ND	SD	1991 Area	ND
		Million acres					
		2.10	2.60	7.00	1.80	13.50	2.90
		Percent					
Corn	Soybean	4	nr	nr	3	1	nr
Corn	Wheat	2	nr	nr	12	2	nr
Corn	Other	1	nr	1	5	1	nr
Soybean	Corn	7	nr	1	10	3	nr
Soybean	Wheat	11	nr	2	4	4	1
Soybean	Other	4	nr	nr	5	2	2
Barley	Wheat	5	nr	5	3	4	3
Barley	Other	10	5	8	4	8	1
Fallow 1/	Wheat	2	58	18	3	21	24
Fallow	Barley	nr	6	4	nr	3	8
Fallow	Fallow	nr	23	1	3	5	2
Fallow	Other	1	3	8	7	6	5
Wheat	Wheat	17	3	16	7	12	22
Wheat	Fallow	2	3	11	3	7	16
Wheat	Barley	4	nr	3	nr	2	2
Wheat	Other	13	1	11	4	9	8
Sunflower	Wheat	3	nr	7	7	5	3
Sunflower	Other	nr	nr	3	nr	1	nr
Sugerbeets	Other	10	nr	nr	nr	2	nr
Drybeans	Other	2	nr	6	nr	3	nr
Sub-total		92	96	91	90	95	81
Other	Other	8	4	9	10	5	19
	Total	100	100	100	100	100	100

nr = None reported. 1/ No crops planted.

Winter Wheat

The two most prominent cropping patterns in the major winter wheat growing states were continuous wheat and wheat-fallow-wheat. These two patterns were practiced on more than 55 percent of 1991 winter wheat acreage (table 13).

In parts of Texas, Kansas, and Oklahoma, there is enough moisture to permit continuous wheat growing. In Oklahoma, 86 percent of the acres planted to wheat in 1991 were used for continuous wheat production, followed by Texas and Kansas with 59 and 45 percent, respectively.

Much of the winter wheat in the United States is grown in the Great Plains, where moisture is limited. Hence, the moisture conserving wheat-fallow-wheat pattern is the most common rotation in this area. The states following this practice include: Oregon (81 percent), Colorado (77 percent), Montana (61 percent), Nebraska (64 percent), South Dakota (44 percent), and Washington (39 percent). Fallowing also helps control weeds, insects, and plant diseases by interrupting their life cycles.

In the Corn Belt, where more moisture is available, corn or soybeans are important winter wheat rotations. In Illinois, 58 percent of 1991 winter wheat acreage grew soybeans in 1990 and corn in 1989. In Ohio and Indiana, 59 and 51 percent, respectively, of the 1991 winter wheat acreage followed this pattern. Soybeans were used in winter wheat rotations in Ohio and Missouri. Barley-fallow-wheat, however, is popular only in Washington and Montana.

Potatoes, and pulses (peas and dry beans) are important components of winter wheat rotation in Idaho and Washington. In Arkansas, 45 percent of the 1991 winter wheat acreage was double cropped. Grain sorghum was the other crop commonly reported in rotation with winter wheat in Arkansas and Texas.

References

1. Gill, Mohinder and Stan Daberkow. "Cropping Pattern Comparisons Between 1989 and 1988", Special Article, Agricultural Resources Inputs Situation and Outlook Re-

Table 13--Cropping patterns used on land producing winter wheat, 1991

Previous crop 1990	Previous crop 1989	AR	CO	ID	IL	IN	KS	MT	MO	NE	OH	OK	OR	SD	TX	WA	1991 Area
		Million acres planted															
		1.10	2.60	0.87	1.65	0.85	11.80	2.35	1.65	2.35	1.15	7.40	0.85	1.50	6.20	2.20	44.52
		Percent															
Corn	Corn	nr	nr	nr	3	7	1	nr	2	nr	nr	1	nr	nr	3	nr	1
Corn	Soybean	nr	nr	nr	5	5	*	nr	6	nr	nr	nr	nr	nr	nr	nr	1
Corn	Other	1	nr	nr	1	4	1	nr	9	nr	4	2	nr	nr	2	nr	2
Wheat 1/	Fallow	nr	5	6	1	nr	9	6	nr	5	1	2	2	11	2	4	5
Wheat	Wheat	1	7	17	3	nr	45	3	2	9	nr	86	4	15	59	14	34
Wheat	Other	3	nr	3	5	2	6	nr	4	1	1	2	1	5	8	3	4
Soybean	Wheat	1	nr	nr	3	nr	nr	nr	10	nr	3	nr	nr	nr	nr	nr	1
Soybean	Soybean	9	nr	nr	8	4	2	nr	12	1	21	nr	nr	nr	1	nr	3
Soybean	Corn	nr	nr	nr	58	51	1	nr	13	nr	59	nr	nr	2	nr	nr	6
Soybean	Other	9	nr	nr	nr	9	1	nr	12	nr	2	nr	nr	nr	nr	nr	1
Fallow 2/	Wheat	nr	77	25	nr	nr	19	61	nr	64	2	nr	81	44	1	39	23
Fallow	Barley	nr	nr	nr	nr	nr	nr	14	nr	nr	nr	nr	nr	2	nr	16	1
Fallow	Sorghum	nr	nr	nr	nr	nr	6	nr	nr	1	nr	nr	nr	2	*	nr	2
Fallow	Corn	nr	2	nr	1	nr	*	nr	nr	5	nr	nr	nr	2	nr	nr	1
Fallow	Fallow	nr	4	1	1	3	1	5	nr	2	1	1	4	3	1	3	2
Fallow	Other	1	2	nr	2	nr	3	2	2	4	nr	1	1	2	1	1	2
Sorghum	Other	8	1	nr	nr	nr	2	nr	5	nr	nr	nr	nr	nr	13	nr	2
Potato	Other	nr	nr	19	nr	nr	nr	nr	nr	nr	nr	nr	1	nr	nr	4	*
Pulses 3/	Other	nr	2	15	nr	nr	nr	nr	nr	1	nr	nr	1	nr	1	11	1
DC 4/	DC 5/	45	nr	nr	1	nr	1	nr	11	nr	nr	2	nr	nr	nr	nr	2
DC	Other	9	nr	nr	3	11	1	nr	8	1	nr	1	nr	nr	nr	nr	2
	Sub-total	87	100	88	95	96	99	96	96	94	94	98	95	94	92	95	96
Other	Other	13	0	12	5	4	1	4	4	6	6	2	5	6	8	5	4
	Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

nr = None reported. * = Less than 1 percent. 1/ Winter wheat planted in fall of 1990. 2/ No crops planted. 3/ Pulses = Dry beans and dry peas. 4/ DC = Double cropping - winter wheat in fall 1990, soybeans in spring/summer 1990. 5/ DC = Double cropping - winter wheat in fall 1989, soybeans in spring/summer 1989.

port, Economic Research Service, U.S. Department of Agriculture. Report No. AR-21, February 1991.

2. Gill, Mohinder and Stan Daberkow. "Crop Sequences Among 1990 Major Field Crops and Associated Farm Program Participation," Special Article, Agricultural Resources, Inputs Situation and Outlook Report, Economic Research Service, U.S. Department of Agriculture. Report No. AR-24, October, 1991.

Tillage Systems

Tillage operations and amount of previous crop residue on the soil surface after planting are important indicators of soil erosion potential. The conservation compliance provisions of the 1985 Food Security Act and the Food, Agriculture, Conservation, and Trade Act of 1990 require farmers to implement conservation practices on highly erodible land (HEL) by 1995 to be eligible for most USDA benefits. To meet these requirements, a change in crop rotation, different tillage system, addition of a cropping practice (such as contouring), and/or installation of permanent structures are recommended. The USDA has assisted farmers in developing conservation plans for 135-140 million acres of highly erodible cropland. These plans include 100 million acres of conservation tillage in the recommendations.

For water erosion control purposes, a conservation tillage system is defined as one that leaves 30 percent or more of the soil surface covered with residue after planting. Conventional tillage methods (with and without the moldboard plow) leave less than 30 percent. Since the various tillage systems leave significantly different residue levels, the type of system directly affects erosion potential and water quality. In general, conventional tillage systems without the moldboard plow leave less than one-half as much residue after planting as mulch-till systems. High residue tillage systems, such as no-till and ridge tillage, can leave as much as 70 percent coverage of the soil surface and offer more protection against erosion than other tillage systems.

Tillage system designations were determined from estimates of residue remaining after planting and the use of specific implements (1). To obtain the residue estimate, the percent of residue remaining was estimated from the previous crop, assumed to be evenly distributed over the soil surface, and re-

duced by the residue incorporation rate of each tillage and planting implement used.

Winter Wheat

Oregon reported the heaviest reliance on the moldboard plow among major states harvesting winter wheat in 1992 (table 14). According to Extension personnel, some western producers believe that the risk of disease is intensified when large amounts of wheat residue are left on the soil surface. Many of these states follow a wheat-fallow or a wheat-wheat-fallow rotation. Colorado, Kansas, and South Dakota reported that mulch tillage was used on more than 20 percent of winter wheat acreage. Ohio and Indiana reported 18 and 17 percent use of no-till, respectively. These states often plant winter wheat after fragile-residue soybeans (table 13). Compared to 1991 acreage, proportional use of the moldboard plow and no tillage remained nearly unchanged, while mulch tillage increased slightly at the expense of conventional tillage without the plow.

South Dakota and Indiana had the highest estimated percent residue remaining after planting (27 and 25 percent, respectively) because of extensive use of mulch-till and no-till methods. Oregon had the lowest (11 percent) because of greater use of conventional tillage methods. There was a slight increase in the area average residue level from 1991.

A slight decrease in the number of trips over the field was reported in 1992, compared to 1991. Except for the no-till system, wheat acreage normally has more trips over the field than most other field crops. This is because much of the wheat produced in the Great Plains and western states is produced after a fallow period (2). All implement trips over the field made during the fallow year were included in determining residue levels. The typical fallow procedure starts in the fall with chisel plowing and other noninversion tillage operations, instead of a single pass with the moldboard plow. For these states, therefore, the tables reflect more trips over the field under conventional tillage without the moldboard plow. An average of 31 percent of the 1992 surveyed winter wheat acres were produced on highly-erodible fields. This figure varied from about 6 percent in Arkansas to 50 percent or more in Idaho, Colorado, Montana, Oregon, and Washington. Conventional tillage methods were used on 73 percent of the highly erodible acreage, down from 82 percent in

Table 14--Tillage systems used in winter wheat production, 1992 1/

Category	AR	CO	ID	IL	IN	KS	MO	MT	NE	OH	OK	OR	SD	TX	WA	Area
Harvested acres (1000)	900	2300	800	1100	450	10900	1350	2250	1950	1140	6000	850	1200	3800	2000	36990
	Percent of acres 2/															
Highly erodible land	6	55	54	31	31	34	30	55	29	9	13	57	16	23	51	31
Tillage system:																
Conv/w mbd plow 3/	nr	5	12	nr	6	13	nr	id	8	id	25	43	nr	2	6	11
Conv/wo mbd plow 4/	96	63	66	77	61	62	73	74	78	66	66	46	59	79	81	68
Mulch-till 5/	nr	29	19	8	16	24	11	18	13	13	9	11	29	18	13	18
No-till 6/	4	3	3	14	17	1	16	7	id	18	nr	nr	12	id	nr	3
	Percent of soil surface covered															
Residue remaining after planting:																
Conv/w mbd plow	nr	2	2	nr	2	2	nr	id	2	id	2	2	nr	1	2	2
Conv/wo mbd plow	11	16	10	17	19	15	18	15	14	14	13	13	18	11	15	14
Mulch-till	nr	39	37	43	40	37	36	41	39	34	37	34	39	42	40	38
No-till	66	57	35	54	55	59	57	68	id	52	nr	nr	68	id	nr	58
Average	14	24	15	25	27	19	26	23	17	23	13	11	30	17	18	19
	Number															
Hours per acre:																
Conv/w mbd plow	nr	.4	.6	nr	.5	.6	nr	id	.9	id	.6	.7	nr	1.1	.9	.6
Conv/wo mbd plow	.3	.4	.4	.3	.3	.5	.3	.3	.6	.4	.6	.5	.4	.6	.5	.5
Mulch-till	nr	.3	.2	.2	.2	.4	.4	.2	.4	.5	.5	.4	.3	.3	.3	.4
No-till	.1	.1	.2	.1	.1	.1	.2	.1	id	.2	nr	nr	.1	id	nr	.1
Average	.3	.3	.4	.3	.3	.5	.3	.3	.6	.4	.6	.6	.3	.5	.5	.5
Times over field:																
Conv/w mbd plow	nr	6.0	4.0	nr	3.9	5.0	nr	id	7.1	id	5.2	5.6	nr	4.3	7.3	5.3
Conv/wo mbd plow	3.5	5.9	3.6	2.5	2.2	5.3	2.4	4.6	5.5	2.5	5.7	6.0	4.9	5.1	5.5	4.9
Mulch-till	nr	4.9	3.5	2.4	2.0	4.6	2.2	2.5	3.7	2.4	4.5	4.9	4.0	3.7	4.4	4.2
No-till	1.0	1.0	1.4	1.0	1.0	1.0	1.0	1.0	id	1.0	nr	nr	1.0	id	nr	1.0
Average	3.4	5.5	3.6	2.2	2.1	5.0	2.2	3.9	5.3	2.3	5.5	5.7	4.2	4.8	5.4	4.7

id = Insufficient data. nr = None reported.

1/ Preliminary. 2/ May not add to 100 due to rounding. 3/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 4/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow. 5/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system. 6/ No-tillage--no residue-incorporating tillage operations performed prior to planting; does allow passes of non-tillage implements, such as stalk choppers.

1991. Only 9 percent used the moldboard plow, 64 percent did not.

Large areas in the western states are usually more subject to wind erosion than to water erosion. A greater proportion of total acreage may be affected because wind erosion is not limited to the more sloping soils. Many western winter wheat producers follow a wheat-fallow rotation. They usually begin the fallow period by roughening the soil by chisel or sweep plowing, leaving residue on the soil surface. This not only decreases wind erosion but helps retain moisture. Winter wheat is planted the following fall and plant growth provides protection during the next spring's critical wind erosion period.

The combination of conventional tillage (especially with the moldboard plow) on highly erodible cropland, creates the potential for significant erosion levels. However, the highly erodible acres which are conventionally tilled should not be interpreted as the acreage that might not be in compliance with the 1985 and 1990 farm bills. If conditions are favorable and the fall-planted winter wheat gets a reasonable start, the growing wheat is probably enough to meet the erosion rate restrictions during critical erosion periods. This is particularly true for the spring wind erosion period in most western states. These acres might meet compliance requirements no matter which tillage system was used.

Other factors also influence erosion rates and would directly relate to meeting conservation compliance requirements. The calculation of the erosion rate considers the entire length of a rotation, not just the current crop and its tillage system. The calculated rate is the average of the sum of the individual rates of each crop, tillage, and practice combination over the life of the rotation. The presence of other practices, such as contouring or terracing, would also reduce the erosion rate. The soil and its erodability characteristics also have a large influence, as does the weather.

At the same time, acres producing winter wheat with conservation tillage would not automatically be in compliance. If the previous crop leaves little residue or any tillage operations leave bare soil during critical erosion periods, even the

Table 15--Tillage systems used in fall potato production, 1991

Category	CO	ID	ME	MI	MN	NY 1/	ND	OR	PA	WA	WI	Area
Planted acres (1000) 2/	71	395	81	35	70	23	155	53	21	144	68	1,116
	Percent of acres 2/											
Highly erodible land	59	43	16	6	5	11	14	33	21	57	3	32
Tillage system:												
Conv/w mbd plow 4/	41	32	40	43	20	78	12	38	96	25	76	34
Conv/wo mbd plow 5/	58	64	43	44	64	22	63	60	3	66	18	56
Mulch-till 6/	id	4	17	10	16	nr	25	id	id	9	6	9
No-till 7/	nr	id	id	id	nr	nr	nr	nr	nr	nr	nr	id
Residue remaining after planting:	Percent of soil surface covered											
Conv/w mbd plow	1	2	2	2	3	2	2	1	2	1	2	2
Conv/wo mbd plow	10	9	8	8	22	6	17	6	8	14	10	12
Mulch-till	id	38	39	41	37	nr	38	id	id	42	41	39
No-till	nr	id	id	id	nr	nr	nr	nr	nr	nr	id	id
Average	7	8	11	10	21	3	20	5	3	13	6	11
	Number											
Number												
Hours per acre:												
Conv/w mbd plow	.7	.8	.9	.8	.6	1.2	.5	1.4	1.2	1.0	.7	.9
Conv/wo mbd plow	.8	.8	.8	1.0	.5	1.0	.4	1.5	1.0	1.0	.7	.8
Mulch-till	id	.6	.8	.8	.4	nr	.4	id	id	.4	.3	.5
No-till	nr	id	id	id	nr	nr	nr	nr	nr	nr	nr	id
Average	.7	.8	.9	.9	.5	1.2	.4	1.5	1.2	.9	.7	.8
Times over field:												
Conv/w mbd plow	3.8	4.2	3.6	4.1	3.7	3.4	4.5	5.4	3.7	4.5	3.5	4.0
Conv/wo mbd plow	4.3	4.7	3.4	3.9	4.1	4.9	4.4	5.5	3.0	4.5	3.2	4.5
Mulch-till	id	3.4	3.0	2.4	3.0	nr	3.1	id	id	2.6	2.1	3.0
No-till	nr	id	id	id	nr	nr	nr	nr	nr	nr	nr	id
Average	4.0	4.5	3.4	3.8	3.8	3.7	4.1	5.4	3.7	4.3	3.4	4.2

id = Insufficient data. nr = None reported.

1/ Excludes Long Island. 2/ Preliminary. 3/ May not add to 100 due to rounding. 4/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 5/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow. 6/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system. 7/ No-tillage--no residue-incorporating tillage operations performed prior to planting; does allow passes of non-tillage implements, such as stalk choppers.

conservation tillage acreage may have erosion rates above compliance limits.

Fall Potatoes

In 1991, Pennsylvania farmers used the moldboard plow on 96 percent of fall potato acreage (table 15). New York and Wisconsin reported use of the plow on over 75 percent of potato acreage. In most other surveyed states, the plow was used on less than 40 percent of the acres. Oregon, Idaho, Washington, and North Dakota reported the largest use of conventional till without the moldboard plow (over 60 percent). No-tillage is still not a common practice among potato growers. In rotations emphasizing potatoes, any decaying vines or tubers left on the fields from previous years may harbor the organisms for early or late blight. In many states, remaining residue averaged less than 10 percent. For all potato production, there was an average of more than four tillage passes.

Wind erosion is a common problem on the flat, loamy-sandy soils used for potato production. Therefore, many of these soils are designated highly erodible. Cover crops, such as rye, are often used as erosion protection in the eastern states where water availability is not a major problem. This may partially explain why in eastern states the moldboard plow is used more extensively. However, in other states, producers have decreased the use of the moldboard plow and retained more crop residue in order to comply with erosion reduction objectives and to conserve moisture.

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Energy

U.S. farmers can expect 1993 energy prices to remain at or slightly above 1992 averages due to steady or slightly higher prices likely for imported crude oil. For 1991, direct energy expenditures (about 3.8 percent of total cash farm production expenses) were approximately 3 percent below those in the preceding year. This fall is attributed to higher energy prices coupled with a slight reduction in energy use due to a decline in the number of acres planted.

The World Crude Oil Price

The world price of crude oil is determined by supply, demand, and other factors such as expectations of market participants. Each factor is a function of substantial uncertainty. For example, current uncertainties concerning oil supply involve oil exports from the former USSR and production from the Organization of Petroleum Exporting Countries (OPEC).

In the former USSR, the production and domestic consumption of crude oil are anticipated to decline. The volume of crude oil available for export will be determined by the decline rate in consumption relative to production and by the need for foreign exchange in the emerging market economies of the new republics.

Two OPEC countries, Kuwait and Iraq, are in the process of restoring their pre-war production capacity and export facilities. Kuwait is expected to increase production and exports as capacity is restored. Iraqi production will be constrained as long as the United Nations embargo against exports remains in effect. Aggregate OPEC production depends on the willingness of other OPEC members to restrain their production, if necessary, as exports from Kuwait, and possibly Iraq, return to the market. OPEC production could also be affected by domestic political problems in Algeria and Venezuela.

The important uncertainties affecting oil demand over the next year or so include the magnitude of economic growth in the United States, Japan, and Western Europe and the severity of winter weather. Two other uncertainties affect the extent to which these supply and demand uncertainties influence crude oil prices: excess crude oil production capacity and stocks of crude oil.

Excess capacity is expected to decrease in 1993 as actual OPEC production exceeds additions to production capacity. During the first half of 1992, concerns grew regarding the possible decline of stocks in the latter half of the year. The concern heightened with the realization that the small excess production capacity (outside of Iraq) might not be used to meet demand. Consequently, world oil prices rose during the second quarter of 1992.

Given these uncertainties, the world price of crude oil is forecast by the Department of Energy to increase between 0 and 8.5 percent through the end of 1993, with the most probable increase being around 3.5 percent.

Domestic Petroleum Consumption and Production

The Department of Energy has analyzed the consumption and production of refined petroleum products in the United States, assuming an average world price of crude oil of $20 per barrel through 1993. With a higher world crude oil price and a sluggish, though rebounding, economy, U.S. petroleum demand is expected to increase. At a world price of $20 per barrel, the demand for all refined petroleum products in 1993 is expected to be 17.32 million barrels per day, a 2.3 percent increase from 1992 (table 16).

Table 16--U.S. petroleum consumption-supply balance

Item	1989	1990	1991	Forecast 1992	Forecast 1993
	Million barrels/day				
Consumption:					
Motor gasoline	7.33	7.23	7.19	7.25	7.30
Distillate fuel	3.16	3.02	2.92	3.01	3.18
Residual fuel	1.37	1.23	1.16	1.14	1.17
Other petroleum 1/	5.47	5.51	5.45	5.53	5.67
Total	17.33	16.99	16.72	16.93	17.32
Supply:					
Production 2/	9.91	9.70	9.90	9.64	9.18
Net crude oil and petroleum imports (includes SPR) 3/	7.20	7.17	6.63	7.17	8.02
Net stock withdrawals	0.21	0.12	0.19	0.12	0.12
Total	17.32	16.99	16.72	16.93	17.32
	Percent				
Net imports as a share of total supply	41.57	42.20	39.65	42.35	46.30
	Percent change from previous year				
Consumption		-1.96	-1.59	1.26	2.30
Domestic production		-2.12	2.06	-2.63	-4.77
Imports		-0.42	-7.53	8.14	11.85

1/ Includes crude oil product supplied, natural gas liquid (NGL), other hydrocarbons and alcohol, and jet fuel. 2/ Includes domestic oil production, NGL, and other domestic processing gains (i.e., volumetric gain in refinery cracking and distillation process). 3/ Includes both crude oil and refined products. SPR denotes Strategic Petroleum Reserves.

Source: U.S. Department of Energy, Energy Information Administration. Short-Term Energy Outlook. DOE/EIA-0202(92/3Q), August 1992.

On the supply side, the $20-per-barrel price will not reverse the rate of decline in domestic crude oil production in 1993. As a result of this, coupled with increased domestic consumption, net crude oil and petroleum imports are expected to increase for 1993 by 11.8 percent.

In the $20-per-barrel-world-oil case, the U.S. price of crude oil is assumed to increase by nearly $1.40 per barrel (3.3 cents per gallon) from the second quarter of 1992 to the fourth quarter of 1993. Most refined petroleum product prices would increase by about 3 cents per gallon during this period due to the higher crude oil price, indicating that the refiner margin would change little. The exceptions are gasoline and diesel fuel. The gasoline price will be subject to additional increases during the winter 1992-1993 due to higher supply costs associated with manufacturing, storing, and transporting gasoline designed to meet Federal requirements for oxygenate content. Although the supply of oxygenates appears to be adequate, the estimated price increase caused by implementation of these rules is about 3 to 5 cents per gallon in the affected regions. The diesel fuel price will be 4 to 7 cents per gallon higher (with the most likely rise about 5 cents) due to Federally mandated lower sulfur content requirements.

At $20 per barrel, the consumption of most refined petroleum products is expected to increase slightly in 1993. In the transportation sector, continued slow economic growth and moderately higher prices for gasoline and diesel fuel are expected to dampen travel demand. Growth in motor-vehicle miles traveled is expected to be more than offset by the continued improvements in vehicle efficiency that reduce gasoline and diesel fuel use. Higher fuel costs are expected to result in higher airline ticket prices, which in turn is expected to keep commercial jet fuel demand weak in 1993.

The slightly higher energy prices are expected to have minimal effect on domestic production of crude oil in 1993. In a $20-per-barrel oil price scenario, domestic crude oil output is projected to decline in 1993 by 460,000 barrels per day from 1991. This compares to a projected average decrease of 260,000 barrels per day in 1992.

At $20 per barrel, net imports of crude oil are anticipated to increase by 850,000 barrels per day to 8.02 million barrels in 1993, compared to an increase of 540,000 barrels in 1992. The expected 1993 increase largely reflects the reduced import rates during the first quarter of 1992, giving a lower base level of imports.

End-of-year crude oil inventories are projected to remain almost unchanged in 1993 at 340 million barrels. Refined petroleum product inventories, however, are expected to increase slightly in 1993 over 1992.

Electricity Prices and Availability

Coal, the dominant fuel type used to generate electricity in the United States, is projected to remain at its 1991 price to electric utilities for the remainder of 1992. This is the result of continuing increases in productivity and available excess coal production capacity offsetting an expected fourth quarter price rise due to an anticipated stock build. The relatively heavy stock build expected in the fourth quarter of this year should put some upward pressure on prices and a prolonged strike (which is possible in early 1993) would have the potential of raising prices in 1993. Otherwise the price of coal should not change significantly in 1993. This being the case, the price of electricity will not change appreciably. The price of electricity, in addition to being a function of the price of fuel, is dependent on interest rates (affecting the cost of capital for expansion and maintenance) and labor rates. Both of these are expected to increase minimally or not at all in 1993.

Generating capacity for electricity is more than adequate to meet expected needs through 1993. Increases in electricity generation are expected to come primarily from coal for the remainder of 1992 and in 1993. Coal generating capacity is expected to continue increasing (at about 0.2 percent per year), while growth in hydroelectric and nuclear sources is

constrained. The decline in hydroelectric generation expected for 1993 is attributed to below normal water conditions in several areas of the country.

Energy in the Farm Sector

The U.S. agricultural sector's energy supply and price expectations reflect world crude oil market conditions. Current world oil supplies are adequate and are expected to continue to be so through 1993. Fuel prices in the farm sector decreased in 1991 from 1990, but are likely to stabilize for the rest of 1992 and in 1993 at or slightly above 1991 levels. Farmers can expect plentiful supplies of gasoline, diesel fuel, and liquefied petroleum (LP) gas this year.

Little shift is expected in the input mix (e.g., fuel choice) over the next year. If crude oil prices go higher, however, farmers will likely substitute relatively less expensive energy (e.g., natural gas) for refined petroleum products where possible.

Farm Fuel Use

Agricultural consumption of refined petroleum products such as diesel fuel, gasoline, and liquefied petroleum gas declined steadily between 1981 and 1989 (table 17). Since then, aggregate energy consumption has remained relatively constant. Although the number of acres planted influences energy use, so do weather and other factors. For example, switching from gasoline to diesel-powered engines, adopting conservation tillage practices, changing to larger, multifunction machines, and creating new methods of crop drying and irrigation contributed to the earlier decline. While no-till and mulch-till farming practices have not been widely adopted, they are as prevalent as conventional tillage practices in some parts of the United States.

With only a minimal variation in total acres planted and harvested, few significant changes in cropping practices, and somewhat higher average energy prices, 1991 farm energy consumption of gasoline, diesel fuel, and LP gas remained near their 1990 levels.

Energy Prices Rose in 1990 and Were Mixed in 1991

Crude oil prices (especially imported crude, since it is the marginal supply in most instances) heavily influence the prices farmers pay for refined petroleum products. Historically, each 1 percent increase in the U.S. price of imported crude oil has translated into about a 0.7 percent rise in the price of gasoline and diesel fuel paid by farmers. In 1990, average gasoline prices increased by 11.4 percent and diesel fuel prices rose by 25 percent over their 1989 levels (table 18). For 1991, gasoline prices were 1.7 percent above their 1990 average while diesel fuel prices fell by 8.4 percent. For the first three quarters of 1992, the price of gasoline is averaging 5.0 percent below its average level for the first three quarters of 1991 while the diesel fuel price is averaging 9.1 percent below its comparable 1991 level.

Energy Expenditures Down in 1991

In 1991, farm energy expenditures on gasoline, diesel fuel, LP gas, electricity, natural gas, and lubricants totaled $7.26 billion, down nearly 3 percent from a year earlier (table 19). This fall reflects a 4.6 percent decline in fuel and lubricant expenditures, a 5.5 percent decrease in electricity expenditures for non-irrigation purposes, and a 16.9 percent jump in

Table 17--Gallons of fuel purchased for on farm use: 1981-1991 1/ 2/

Year	Gasoline	Diesel Fuel	LP Gas
		Billion gallons	
1981	2.7	3.1	1.0
1982	2.4	2.9	1.1
1983	2.3	3.0	0.9
1984	2.1	3.0	0.9
1985	1.9	2.9	0.9
1986	1.7	2.9	0.7
1987	1.5	3.0	0.6
1988	1.6	2.8	0.6
1989	1.3	2.5	0.7
1990	1.5	2.7	0.6
1991	1.4	2.8	0.6

1/ Excludes Alaska and Hawaii
2/ Excludes fuel used for household and personal business

Source: U.S. Department of Agriculture, National Agriculture Statistics Service, Farm Production Expenditures, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, and 1991 summaries.

Table 18--Average U.S. farm fuel prices 1/

Year	Gasoline	Diesel	LP gas
		$/gallon 2/	
1981	1.29	1.16	0.70
1982	1.23	1.11	0.71
1983	1.18	1.00	0.77
1984	1.16	1.00	0.76
1985	1.15	0.97	0.73
1986	0.89	0.71	0.67
1987	0.92	0.71	0.59
1988	0.93	0.73	0.59
1989	1.05	0.76	0.58
1990	1.17	0.94	0.83
1991	1.19	0.87	0.75
Jan 1991	1.26	1.05	0.88
April 1991	1.16	0.82	0.72
July 1991	1.16	0.77	0.68
Oct 1991	1.16	0.85	0.73
Jan 1992	1.08	0.77	0.75
April 1992	1.11	0.79	0.71
July 1992	1.21	0.84	0.69

1/ Based on surveys of farm supply dealers conducted by the National Agricultural Statistics Service, USDA. 2/ Bulk delivered.

expenditures on electricity for irrigation. Total expenditures on electricity, however, fell by about 1 percent. Higher energy prices and yields and a slight fall in acres planted and harvested in 1991 over 1990 accounted for these reductions. For 1992, a moderate increase in planted acreage and relatively higher energy prices during the planting season will likely result in a 1.9 percent rise in farm energy expenditures.

Farm Machinery

The farm machinery sales slump continued through September as farmers avoided purchasing capital equipment. Apprehension about the general economy is one possible factor in farmers' caution in making large capital investments in equipment. Concern about drought impacts in some parts of the country and anxiety about falling commodity prices and rising machinery prices are also factors. Late harvests in some parts of the country may be delaying capital investment for some farm machinery. Furthermore, farm income in 1991 and projected 1992 farm income are below the levels experienced in 1990.

On the other hand, some economic factors are favorable and may encourage increased capital investment in coming months. Interest rates are the lowest they have been in several years. The value of farm assets is up, and debt is relatively low, increasing farm equity and improving farmers' ability to borrow. Also, the stock of farm machinery and equipment in the United States is aging, and while farmers can keep it running with repairs and careful maintenance, in the long run it must be replaced. The question is when.

Table 19--Farm energy expenditures

Item	1988	1989	1990	1991	Forecast 1992
			$ billion		
Fuels and lubricants:					
Gasoline	1.42	1.44	1.65	1.50	1.48
Diesel	2.12	2.12	2.42	2.34	2.40
LP gas	0.38	0.38	0.53	0.44	0.47
Other	0.53	0.51	0.57	0.65	0.65
Electricity:					
Excluding irrigation	2.17	1.69	1.65	1.57	1.61
For irrigation	0.48	0.64	0.65	0.76	0.78
Total	7.10	6.78	7.47	7.25	7.39
Percent change from preceding year		-4.51	10.18	-2.95	1.93

Source: U.S. Department of Agriculture, National Agriculture Statistics Service, Farm Production Expenditures, 1987, 1988, 1989, 1990, and 1991 summaries.

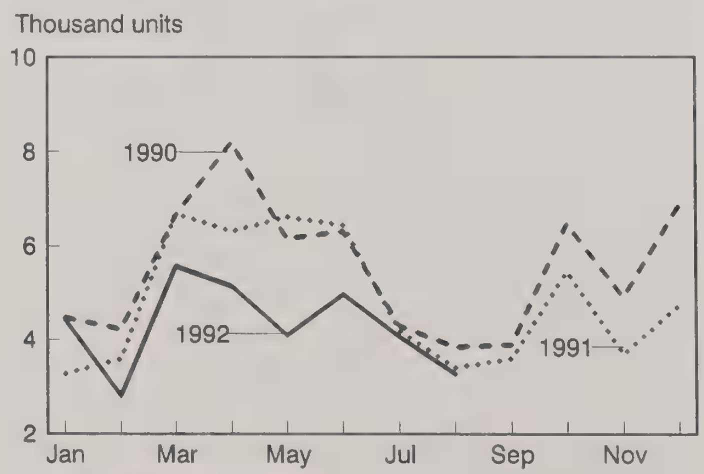
Unit Sales

The first 8 months of the year showed a marked decrease in sales of tractors and combines from the corresponding period a year ago (figure 1). Sales of tractors, 40-100 horsepower, totaled 23,200 units by the end of August, compared to 24,400 units in August 1991. Sales of tractors 100 horsepower and over totaled 9,520 units, compared to 13,560 units in July 1991. Four-wheel-drive sales were 37 percent below 1991, to 1,640 units. Combine sales fared even worse. In 1992 sales were 3,550 units by the end of August compared to 5,880 units from the 1991 corresponding period, a 40 percent drop.

The slump in sales will likely continue through the end of the year with a forecast decrease of 8 percent for all farm tractors from 1991 and a 21 percent decrease for combines (table 20). While the 1992 forecast in unit tractor sales is down 8 percent, compared to 7 percent at the beginning of the year, the two forecasts are not as close as they seem. The largest unit sales class, 40-100 horsepower, was earlier forecast to decrease 11 percent, but has been doing better than expected, and is now forecast down 2 percent. The smallest category, four-wheel-drive, was forecast to decrease 7 percent and is now forecast down 22 percent.

A look at the historic data show that when sales of tractors go down, large (over 100 horsepower) tractor sales go down proportionately more than the smaller 40-100 horsepower category. The reverse trend occurs when farmers buy more tractors. Proportionately more large tractors are sold when total sales increase.

Figure 1
Farm Tractor Sales 1/



1/ Wheel tractors 40 horsepower and above.
Source: Equipment Manufacturers Institute.

Factors Affecting Sales

Economy

The general economic climate appears to have slowed sales of farm machinery in 1992. The lagging economy affects everyone's buying decisions. Farmers are reluctant to invest in expensive capital investment items when they are not sure how long the economy will remain in a slowdown.

Income and Cash Receipts

Another factor affecting sales of farm machinery is income. After record highs in 1990, both net cash income and net farm income declined in 1991 (table 21). The 1992 forecasted range includes a possible rise in net farm income. Higher income increases purchases of farm machinery. Net cash income includes cash receipts minus cash expenses. Net farm income includes inventory adjustments, and non-

Table 20--Domestic farm machinery unit sales

Machinery category	1985	1986	1987	1988	1989	1990	1991	1992F	Change 90-91	Change 91-92
	Units								- - % - -	
Tractors:										
Two-wheel-drive										
40-99 hp	37,800	30,800	30,700	33,100	35,000	38,400	33,900	33,400	-12	-2
100-139 hp 1/	7,300	5,100	5,100	4,300	5,200					
Over 139 hp 1/	10,400	9,100	10,800	11,800	15,400					
Total over 99 hp	17,700	14,300	15,900	16,100	20,600	22,800	20,100	16,900	-12	-16
Four-wheel-drive	2,900	2,000	1,700	2,700	4,100	5,100	4,100	3,200	-20	-22
All farm wheel tractors	58,400	47,100	48,400	51,700	59,700	66,300	58,100	53,500	-12	-8
Grain and forage harvesting equipment:										
Self-propelled combines	8,400	7,700	7,200	6,000	9,100	10,400	9,700	7,700	-7	-21
Forage harvesters 1/2/	2,500	2,200	2,300	2,400	2,800					
Haying equipment:										
Mower conditions 1/	11,200	10,900	11,200	11,000	13,200					

1/ Discontinued after 1989. 2/ Shear bar type.

Source: Equipment Manufacturers Institute (EMI). All 1992 values are ERS forecasts.

Table 21--Trends in U.S. farm investment expenditures and factors affecting farm investment demand

Item	1985	1986	1987	1988	1989	1990	1991P	1992F
				$ billion				
Capital expenditures:								
Tractors	1.94	1.51	2.10	2.48	2.76	2.90	2.4	1.9-2.3
Other farm machinery	3.23	3.09	4.30	4.15	4.92	5.31	4.6	4.3-4.8
Total	5.17	4.60	6.40	6.63	7.68	8.21	7.0	6.2-7.1
Tractor and machinery repairs	3.44	3.43	3.54	3.59	3.96	3.76	3.8	3.7-4.0
Trucks and autos	1.76	1.71	2.17	2.34	2.50	2.51	2.3	2.1-2.5
Farm buildings 1/	2.26	2.14	2.60	2.35	2.45	2.67	2.6	2.4-2.8
Factors affecting demand:								
Interest expenses	18.6	17.1	15.0	14.7	14.7	14.5	14	12-14
Total production expenses	132.4	125.5	128.8	134.3	141.2	145.1	145	145-149
Outstanding farm debt 2/ 3/	187.9	166.6	153.7	148.5	146.0	145.1	147	145-151
Farm real estate assets 2/	657.0	613.0	658.6	682.2	703.9	711.4	706	705-715
Farm nonreal estate assets 2/	235.8	234.7	252.7	269.3	281.9	292.2	299	300
Agricultural exports 4/	31.2	26.3	27.9	35.3	39.6	40.2	38	41
Cash receipts	144.1	135.2	141.8	151.1	161.0	169.9	167	164-168
Net farm income	31.0	31.0	39.7	41.1	49.9	51.0	45	42-47
Net cash income	47.9	46.7	55.8	58.1	58.9	61.3	58	54-57
Direct government payments	7.7	11.8	16.7	14.5	10.9	9.3	8	9-10
				Million acres				
Idled acres 5/	30.7	48.1	76.2	77.7	60.8	61.6	64.5	53.7
				Percent				
Real prime rate 6/ 7/ 9/	6.9	5.7	5.0	5.4	6.5	5.7	4.4	3.6
Nominal farm machinery and equipment loan rate 7/ 10/	13.7	12.2	11.5	11.7	12.8	12.3	11.3	9.9
Real farm machinery and equipment loan rate 6/ 10/	9.6	9.4	8.0	8.4	8.4	8.0	7.2	7.0
Debt-asset ratio 8/	21.0	19.7	16.9	15.6	14.8	14.5	14.6	14-15

1/ Includes service buildings, structures, and land improvements. 2/ Calculated using nominal dollar balance sheet data, including farm households for December 31 of each year. 3/ Excludes CCC loans. 4/ Fiscal year. 5/ Includes acres idled through commodity programs and acres enrolled in the Conservation Reserve Program. 6/ Deflated by the GDP deflator. 7/ Average annual interest rate. From the quarterly sample survey of commercial banks: Agricultural Financial Databook, Board of Governors of the Federal Reserve System. 8/ Outstanding farm debt divided by the sum of farm real and nonreal estate asset values. 9/ First half 1992. 10/ First quarter 1992.
P-preliminary. F-forecast.

Source: Agricultural Income and Finance, Situation and Outlook Reports, ERS; and other ERS sources.

money income, such as the value of home consumption of farm products and an imputed rental value on operator dwellings.

The 1991 decrease in income is largely the result of lower cash receipts, primarily due to declines in livestock receipts. Cash receipts for crops have been holding steady at $80 billion since 1990, and may increase in 1992. Total expenses were unchanged from 1990 to 1991. A decrease in direct government payments contributed to the 1991 income decrease.

Prices

Prices for some commodities have been declining from those of a year ago. Wheat and corn prices are down, largely because of higher yields, increasing production, and prospective larger carryover stocks. Decreased commodity prices, and farmer anticipation of even lower prices, discourages purchases of farm machinery and equipment.

Prices of farm machinery, on the other hand, have been rising (table 22). The July 1992 prices-paid index for trucks and autos, at 262, was up 18 points over 1991. Increases in prices of farm machinery have a dampening effect on demand.

Farm Equity

Farm equity is the net worth of the farm sector and includes assets minus debt. Total farm equity has increased every year since 1986 and probably will continue in 1992. Increased equity implies more collateral to finance farm machinery loans.

Assets, at an all time high of $1,089 billion in 1981, decreased to a 6 year low of $848 billion in 1986, and then climbed to $1,004 billion in 1991. Assets are composed of both real estate ($706 billion in 1991) and non-real estate ($299), including livestock, household items, and machinery. While total 1991 assets were up, real estate assets were down $5.8 billion from 1990. The increase in total 1991 assets was primarily due to larger household and financial assets. Total assets are forecast to increase again in 1992.

Table 22--Prices paid for trucks, tractors, and other farm machinery

Year	Trucks and autos	Tractors and self-propelled machinery	Other machinery
		1977 = 100	
1980	123	136	132
1981	143	152	146
1982	159	165	160
1983	170	174	171
1984	182	181	180
1985	193	178	183
1986	198	174	182
1987	208	174	185
1988	215	181	197
1989	223	193	208
1990	231	202	216
1991	244	211	226
1992 July	262	217	234

Source: National Agricultural Statistics Service, USDA.

Farm debt, at an all-time high in 1983 ($207 billion), has since decreased every year until 1990 ($145 billion). In 1991 debt rose to $147 billion and probably will be up further in 1992. Lower debt improves farmers' borrowing position with lenders.

A common indicator of the economic health of the farm sector is the debt-asset ratio. At an all-time high ratio of 23 in 1985, it fell to 14.6 in 1991 and will likely hold steady in 1992. To find lower debt-asset ratios, one must go back to the early 1960s and beyond. Ratios of 14 or lower have been favorable toward the purchase of farm machinery.

Interest Rates

The second favorable factor, which usually means increased purchases of farm machinery, is lower interest rates. The real (adjusted for inflation) prime rate was down again the first half (3.6 percent) and will likely show a significant 1992 decrease from 1991. It will be the third consecutive yearly decrease in the prime rate since 1989.

The prime rate portends changes in the farm nominal machinery loan rate, which has also been down in recent years. While the real rate reflects the actual cost of borrowing, the nominal rate probably more directly affects machinery purchases since it is more obvious to farmers. From almost 18 percent in 1981, the nominal farm machinery loan rate has decreased to 9.9 percent in the first quarter of 1992. Interest rates are negatively correlated with purchases of farm machinery. As interest rates fall, the total cost of machinery bought on credit decreases, facilitating increased purchases.

Aging Machinery Stock on Farms

Many analysts think that the average stock of machinery on farms has aged to the point where it is inefficient to keep repairing old machinery and that farmers would benefit by trading in old equipment for new. But the optimal time to buy is complicated by several factors. Hours of use has more to do with determining the optimal time to buy than age. It is the hours of use that wear out machinery, not age.

While it is difficult to obtain reliable information on the age of machinery across the country, it is even harder to get information on hours of use. There is evidence that hours of use has decreased nationally, especially since 1979. Reduced tillage or conservation tillage has increased significantly in the U.S. in recent years. Reduced tillage results in fewer times over with cultivation equipment, decreasing hours of use. Also, a trend toward larger tractors and equipment means that more acres can be covered in less time, also reducing

hours of use. In addition, there may be evidence that farm machinery is becoming more durable, again increasing hours of use. These factors all tend to increase the optimal replacement age of tractors and equipment, or in economic jargon, lengthen the real depreciation schedule.

The effect of age, or hours of use, on decisions to purchase new equipment is not easy to assess. Farmers are likely to keep their equipment longer now than they did before the late 1970's. Yet there comes a time when equipment must be replaced. As farm machinery continues to age, potential demand for new equipment should grow stronger.

Commodity Exports

Another factor that may have a positive bearing on purchases of farm machinery is commodity exports. Commodity exports are forecast at $41 billion in 1992, up from $38 billion in 1991. The export increase is due, in part, to forecast increases in exports of wheat, flour, and oilseeds, which more than offset forecast declines in cotton and feed grains.

Farm Machinery Trade

Farm machinery imports totaled $1.9 billion in 1991 and exports were $3.0 billion, $1.1 billion more than imports (table 23). Both imports and exports decreased from the previous year, $514 million and $186, respectively. The 1992 U.S. Industrial Outlook, U.S. Department of Commerce, shows exports of farm machinery exceeding imports every year, 1989 through 1991. Exports are forecast to exceed imports again in 1992. Imports of farm machinery are forecast at $2.3 billion in 1992 and exports at $3.1 billion, $800 million above imports.

Farm machinery exports declined for most categories from 1990 to 1991. However, most categories have increased during the first 7 months of 1992 from the same period a year ago. All exports were up $144 million, January through July, 1992. Imports of farm machinery were also down in 1991 and continued the downward trend through the first 7 months of 1992. While most import categories were down some in 1991, harrow and cultivator imports decreased the most, 43 percent.

The largest import category is tractors and exports is equipment parts and components. Tractor imports totaled $972 million in 1991, and were primarily from Germany and the United Kingdom, in the 40 to 100 horsepower range. Exports of tractors totaled $390 million, with about one-third going to Canada. The U.S. also exported many tractors to Germany, France, the Netherlands, the United Kingdom, and Australia.

Table 23 --Farm machinery exports and imports.

Item	1990	1991	January-July 1991	January-July 1992
	Million dollars			
Exports:				
Total	3,147	2,961	1,778	1,922
Tractors 1/	398	390	229	277
Tractors, used 1/	39	40	25	23
Combines-harvesting equip.	292	279	176	178
Balers	72	59	39	42
Mowers	42	46	33	36
Haying equipment	31	23	18	16
Plows 2/	10	11	6	6
Harrows and cultivators	13	16	9	11
Spraying equipment	55	89	50	60
Seeding and planting equip.	70	73	46	56
Livestock equipment	308	244	150	176
Equip. parts & components	1,816	1,691	997	1,041
Imports:				
Total	2,364	1,850	1,216	1,195
Tractors 1/	1,225	972	663	620
Tractors, used 3/	13	12		
Combines-harvesting equip.	72	57	40	37
Balers	10	[illegible]	6	4
Mowers	77	60	46	43
Haying equipment	14	14	12	5
Plows 2/	26	20	11	7
Harrows and cultivators	136	77	46	36
Spraying equipment	32	32	23	29
Seeding and planting equip.	63	38	24	26
Livestock equipment	103	82	52	51
Equip. parts and components	592	477	294	336

1/ Does not include track laying tractors.
2/ Includes moldboard, disk and other plows.
3/ January-July, unavailable.

Source: International Trade Commission and official statistics of the U.S. Department of Commerce.

Seeds

Consumption

In the 1991/92 crop year, seed consumption for eight major field crops was close to 6.0 million tons, up 1 percent from the previous year (table 24). Increased seed use this year resulted from gains in wheat, corn, rice, and sorghum planted acreage. However, barley, oats, and cotton planted acreage declined and soybean planted acreage remained virtually unchanged from a year earlier.

Prices

Higher corn, grain sorghum, small grains, and cotton seed prices in 1992 were offset by much lower seed potato, soy-

Table 24--Seed use for major U.S. field crops 1/

Crops	1988/89	1989/90	1990/91	1991/92 2/	1990/91-1991/92
	1,000 tons				% Change
Corn	515	529	540	566	5
Sorghum	42	36	39	48	23
Soybeans	1,747	1,664	1,701	1,700	0
Barley	360	324	350	307	-12
Oats	433	374	306	290	-5
Wheat	3,090	3,009	2,709	2,811	4
Rice	150	160	168	174	4
Cotton 3/	112	94	108	102	-6
Total	6,449	6,190	5,921	5,998	1

1/ Crop marketing year. 2/ Preliminary. 3/ Upland cotton.

beans, and most of the forage seeds prices (table 25). As a result, the April 1992 prices-paid index for all seeds at 162, was 1 point lower than previous year.

Hybrid seed prices, such as corn and grain sorghum, reflect several supply and demand factors. For example, weather conditions that either inhibit or enhance yields of commercial crops of corn and sorghum, also affect the seed supply the following year. Furthermore, hybrid seeds are purchased each year and are not grown on the farm. This reduces farmers seed source options.

Non-hybrid seed prices tend to follow commodity prices. For example, oats, barley, spring wheat, and cotton seed prices jumped 15, 12, 28, and 2 percent respectively between April 1991 and April 1992 (table 25). Prices received by farmers for each of these commodities also increased between the 1990/91 and 1991/92 marketing years, reflecting increased demand. Farmers have the option to save seed from current production for the following year's crop, which results in a linkage between seed and commodity prices.

Forage seed prices in 1992 fell compared to 1991; as demand declined due to slow growth of Conservation Reserve Program (CRP). In 1992, only 989,211 acres are enrolled in CRP and 10 percent of this area is to be planted to trees. Very slow growth in CRP-related grass demand and plentiful forage seed supplies contributed to the decline of forage seed prices. For example, tall fescue, red clover, lespedeza, annual ryegrass, and alfalfa prices fell 24, 9, 8, 6, and 5 percent respectively.

Table 25--April farm planting seed prices 1/

Item	Unit	1989	1990	1991	1992	Change 91-92
						%
Field seeds:						
Corn	2/	71.40	69.90	70.20	71.80	2
Grain sorghum	$/cwt.	69.50	69.90	71.20	72.30	2
Oats	$/bu.	5.89	4.19	3.71	4.26	15
Barley	$/bu.	5.91	5.25	4.55	5.10	12
Wheat (spring)	$/bu.	6.71	6.05	4.72	6.06	28
Wheat (winter)	$/bu.	7.55	8.01	6.89	7.41	8
Soybeans	$/bu.	14.70	12.50	12.80	12.40	-3
Cotton	$/cwt.	50.10	54.30	58.20	59.70	3
Potatoes	$/cwt.	10.60	11.00	9.70	6.95	-28
Forage seeds:						
Red clover	$/cwt.	162.00	145.00	134.00	122.00	-9
Fescue, tall 3/	$/cwt.	111.00	85.10	89.00	67.80	-24
Orchardgrass	$/cwt.	117.00	102.00	101.00	100.00	-1
Ryegrass, annual	$/cwt.	54.30	50.50	46.80	43.80	-6
Timothy	$/cwt.	132.00	82.10	66.40	66.30	0
Lespedeza, sericea	$/cwt.	167.00	134.00	101.00	92.80	-8
Alfalfa, proprietry	$/cwt.	249.00	253.00	266.00	252.00	-5
Seed price paid index (1977=100)		170	163	163	162	-1

1/ Derived from the April survey of farm supply dealers conducted by NASS, USDA. 2/ $/80,000 kernels. 3/ Alta and Kentucky 31.

Table 26--U.S.farm expenditures for seeds 1/

Item	1987	1988	1989	1990	1991	Change 90-91
	Billion $					%
Field crops and small grains	2.46	2.49	2.77	2.67	2.84	6
Legumes, grasses, and forages	0.39	0.34	0.34	0.33	0.28	-15
Seeds and plants for other crops	0.65	0.78	0.67	0.88	1.17	33
Other seed expenses 2/	0.05	0.09	0.08	0.05	0.08	60
Total seed expenditures	3.54	3.69	3.86	3.93	4.37	11

1/ Excludes bedding plants, nursery stocks, and seed purchased for resale.
2/ Includes seed treatment.

Source: U.S. Department of Agriculture, NASS. Farm Production Expenditures, 1991 Summary.

Expenditures

In 1991, total farm seed expenditure was $4.4 billion, up 11 percent from previous year (table 26). Field-crops and small-grain seed expenditure rose 6 percent in 1991, due to their higher seed prices. A sharp increase of 33 percent expenditure in seeds and plants for other crops also contributed to the higher total farm seed expenditures. In 1992, total farm seed expenditures are expected up because of 5, 4, and 23 percent increases in planted acreage of corn, wheat, and sorghum, respectively.

1991 Fall Potato Seeding Rates and Seeding Cost Per Acre

Fall potatoes are grown predominantly in 11 states (table 27). In 1991, these states planted 93 percent of the total fall potato acreage. The average seeding rate in 1991 was 20 cwt per acre, the same as in 1989 and 1990. However, potato seeding rates among the 11 surveyed states vary widely due to moisture availability. For example, New York and Maine, where rainfall is adequate, support higher seeding rates. Colorado, Oregon, and Washington tend to have higher seeding rates because potatoes are irrigated. Less moisture, on the other hand, means lower seeding rates per acre - - North Dakota and Minnesota producers seed at an average rate of 16 and 17 cwt per acre, respectively.

Seeding rates and seed prices are the principal determinants of seed cost. In 1991, the average seed cost per acre was $186, down 17 percent from a year earlier as seed prices declined 28 percent. Among states, differences in seed potato prices and seeding rates resulted in per acre cost ranging from $121 for North Dakota to $278 for Washington. Aver-

Table 27--Fall potato seeding rates, seed cost per acre, and percent purchased, 1991 1/

States	Acres planted 2/	Rate per acre	Cost per acre 3/	Acres with purchased seed
	1,000	Cwt	$	%
Colorado	71	24	232	36
Idaho	395	20	159	91
Maine	81	21	199	71
Michigan	35	19	195	79
Minnesota	70	17	155	87
New York 4/	23	25	272	86
North Dakota	155	16	121	84
Oregon	53	22	234	97
Pennsylvania	21	20	243	91
Washington	144	22	278	99
wisconsin	68	19	175	86
1991 Average	1,116	20	186	85
1990 Average	1,087	20	224	85
1989 Average	1,011	20	189	83

1/ States in survey planted 93 percent of the fall potato acreage in 1991. 2/ Preliminary. 3/ Based on data from those farmers who used purchased seed. 4/ Excludes Long Island.

Table 28--Winter wheat seeding rates, seed cost per acre, and percent of seed purchased, 1992 1/

States	Acres	Rate per acre	Cost per acre 2/	Acres with purchased seed
	1,000	lbs.	$	%
Arkansas	900	127	16.19	75
Colorado	2,300	42	2.88	38
Idaho	800	85	11.19	70
Illinois	1,100	102	14.71	69
Indiana	450	117	18.89	89
Kansas	10,900	63	6.49	28
Missouri	1,350	108	14.36	61
Michigan	2,250	60	4.96	30
Nebraska	1,950	67	5.33	34
Ohio	1,140	134	18.61	72
Oklahoma	6,000	73	5.18	22
Oregon	850	76	9.18	64
South Dakota	1,200	72	5.09	38
Texas	3,800	69	6.15	37
Washington	2,000	66	7.73	71
1992 average	36,990	73	8.71	39
1991 average	34,180	74	8.65	36

1/ Preliminary. States listed harvested 87 percent of U.S. winter wheat acres in 1992. 2/ Based on data from those farmers who used purchased seed.

age cost per acre in 1992 is likely to fall from 1991 levels because of lower prices.

Farmers used purchased seed potatoes for 85 percent of the 1991 fall potato crop. However, in Colorado, farmers used homegrown seed potato on 64 percent of the potato acreage. Colorado producers grow a large share of their own seed, which is typically one or two generations away from certified seed.

Winter Wheat Seeding Rates and Seed Cost Per Acre in 1992

The average winter wheat seeding rate was 73 pounds per acre in 1992, about the same as last year. The average cost, however, was $8.71 per acre, higher than the 1991 cost per acre. This was due to 7 percent increase in winter wheat seed price in 1992 (table 28).

Seeding rates and costs per acre varied widely among surveyed states. Indiana, Arkansas, Illinois, Ohio, and Missouri had higher seeding costs, because of higher seeding rates per acre. Similar pattern was observed in 1991. Indiana had the highest cost, $18.89 per acre, although the seeding rate was third highest, behind Ohio and Arkansas. Colorado, on the other hand, had the lowest seeding rate and cost per acre.

Farmers used purchased seed on an average of 39 percent of the 1992 winter wheat acreage. Indiana showed the highest percent (89 percent) and Oklahoma the lowest (22 percent). Local economic situations, prices, and yield of purchased seed apparently account for much of the regional variations.

U.S. Seed Exports and Imports

Corn Seed Exports

In 1991, the volume of U.S. field corn seed exports to the 12 leading importers rose to 81,337 metric tons, a jump of 35 percent from 1990. This increase reflects plentiful supplies in the United States and strong demand abroad. These 12 countries accounted for 87 percent of U.S. total corn seed exports in 1991 (table 29). Although exports to Mexico and Spain fell 23 and 50 percent, respectively, sharp increases to Canada, France, Unified Germany, Netherlands, Greece, former USSR, and Turkey more than offset these declines. The result was a 33 percent increase in total volume of U.S. corn seed exports in 1991.

Total corn seed exports to major trading partners fell 31 percent in the first 6 months of 1992 over the corresponding period of 1991. Exports to former USSR and Eastern European countries fell, because of their limited buying power due to scarce hard currency. Over this same time frame, total exports to all countries fell 35 percent. Although exports to Canada, Spain, Turkey, and Japan jumped 105, 37, 127, and 20 percent, respectively, in first-half 1992 over the corresponding 1991 period, these increases were not enough to offset the overall decline.

Corn Seed Imports

The volume of total corn seed imports in 1991 fell 22 percent to 10,978 metric tons, because of larger domestic seed stocks (table 30).

Canada, Argentina, Chile, and Hungary are the major suppliers of corn seed imports. In 1991, these countries supplied nearly 95 percent of total U.S. imports. However, these imports constitute a very small part of total U.S. seed consumption.

Corn seed imports from Argentina and Chile rose sharply in the first 6 months of 1992 compared to the corresponding period of 1991. This sharp increase in corn seed imports from

Table 29--U.S. corn seed exports by volume

Country	1989	1990	1991	Change 90-91	January-June 1991	January-June 1992	Change 91-92
	--------Metric tons--------			%	-----Metric tons-----		%
Canada	1,548	4,076	7,561	86	2,807	5,768	105
Mexico	10,205	10,329	7,963	-23	6,104	5,760	-6
France	2,873	9,666	10,953	13	3,840	2,408	-37
Germany	522	1796	8,822	391	8,150	979	-88
Spain	1,836	4,132	2,076	-50	1,332	1,821	37
Italy	12,168	20,889	21,773	4	11,004	9,809	-10
Netherlands	351	2,437	10,354	325	1,973	247	-87
Greece	1,999	1,828	4,072	123	2,814	2,163	-23
Romania	107	1,050	2,532	141	2,530	191	-92
Union of Soviet Socialist Rp.	0	2,459	3,569	45	3,569	353	-90
Turkey	245	59	171	190	171	388	127
Japan	1,051	1,431	1,491	4	630	757	20
Subtotal	32,905	60,152	81,337	35	44,924	30,644	-31
Total all countries	36,859	70,366	93,722	33	52,676	34,234	-35

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

Table 30--U.S. corn seed imports by volume

Country	1989	1990	1991	Change 90-91	January-June 1991	January-June 1992	Change 91-92
	-----Metric tons-----			%	-Metric tons-		%
Canada	7,753	8,010	6,857	-14	3,940	1,981	-50
Argentina	2,457	511	138	-73	138	4,804	3381
Chile	7,000	4,509	3,406	-24	3,362	13,496	301
Hungary	3,708	881	0	-100	0	391	na
Subtotal	20,918	13,911	10,401	-25	7,440	20,672	178
Total all countries	22,672	13,996	10,978	-22	7,913	21,387	170

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

Table 31--U.S. soybean seed exports by volume

Country	1989	1990	1991	Change 90-91	January-June 1991	January-June 1992	Change 91-92
	-----Metric tons-----			%	-Metric tons-		%
Canada	390	449	425	-5	425	1178	177
Mexico	100,380	36,731	4,827	-87	4,515	31,670	601
France	1,698	4,827	4,272	-11	3,948	584	-85
Italy	20,185	55,937	65,571	17	56,757	32,807	-42
Turkey	2,777	2,835	1,838	-35	1,838	6,985	280
Japan	1,608	2,325	6,947	199	3,480	1,083	-69
Subtotal	127,038	103,104	83,880	-19	70,963	74,307	5
All countries Total	128,582	106,991	91,004	-15	76,688	72,808	-5

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

Argentina and Chile is due to the entry of off-season production to satisfy increased corn acreage demand in 1992.

Soybean Seed Exports

In 1992, 92 percent of U.S. soybean seeds were shipped to 6 major trading partners: Italy, France, Japan, Mexico, Turkey, and Canada. The volume of soybean seed exports to these countries was 83,880 metric tons, a decline of 10 percent from the previous year. Over the same period, total export to all countries declined 15 percent (table 31).

Sharp increases in soybean seed exports to Canada, Mexico, and Turkey in the first 6 months of 1992 over 1991 offset declines in exports to France, Italy, and Japan. As a result, exports to the six leading countries increased 5 percent, while overall soybean seed exports fell 5 percent.

Total Exports

In 1991, the value of the total seed exports rose to $672 million, an increase of 14 percent from a year earlier. This increase primarily reflects gains in vegetable, corn, and sugarbeet seed exports. These gains, however, were partly offset by 3 and 9 percent declines in forage and soybean seed exports (table 32).

Italy, Mexico, Canada, France, and Netherlands continued to be the top markets for U.S. planting seeds in calendar year 1991. However, for the last 3 years, Saudi Arabia, with about 10 percent of the total seed-for-planting shipments, was also among the top markets. These countries together accounted for about 70 percent of the total export value (table 33). Italy, with 16 percent of the total export value, led the market, followed by Mexico with 13 percent. Third position was held by Canada with 10 percent of the total value of seed exported, while Saudi Arabia followed with 9.

On a regional basis, North and Central America, Western Europe, and Asia typically account for about 90 percent of the total value of seed exports.

Table 32--Exports and imports of U.S. seed for planting

Item	1988	1989	1990	1991	Change 90-91
	--------$ million------				%
Exports:					
Forage	94	96	104	101	-3
Vegetable	167	153	176	220	25
Flower	9	11	13	14	8
Corn 2/	67	68	138	181	31
Grain sorghum	29	55	27	28	4
Soybean	26	54	45	41	-9
Tree/shrub	3	4	2	2	0
Sugarbeet	2	1	2	3	50
Other	27	68	81	82	1
Total	424	510	588	672	14
Imports:					
Forage	52	44	35	31	-11
Vegetable	58	56	60	79	32
Flower	21	24	23	24	4
Corn 3/	10	37	18	15	-17
Tree/shrub	2	2	2	2	0
Other	4	6	9	14	56
Total	147	169	147	165	12
Trade balance	277	341	441	507	15

1/ Totals may not add due to rounding. 2/ Not sweet, not food aid. 3/ Certified.

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

Table 33--Export U.S. seeds for planting; region and country share, by value 1/

Region/country	1987	1988	1989	1990	1991
North and Central America:					
Canada	9.4	8.3	6.2	10.2	9.9
Mexico	13.0	12.6	25.4	14.4	13.0
Others	2.3	2.1	1.8	1.8	1.5
Total	24.7	23.0	33.4	26.3	24.4
South America:					
Brazil	1.2	1.2	0.6	0.5	0.5
Argentina	2.5	3.0	2.0	1.7	1.4
Colombia	0.9	1.1	0.6	0.5	0.6
Venezuela	1.4	3.3	0.6	0.4	0.6
Others	1.5	1.5	1.4	0.5	0.5
Total	7.6	11.5	6.5	4.9	4.7
Western Europe:					
United Kingdom	2.6	2.9	2.6	1.9	1.7
Netherlands	5.4	4.4	4.2	4.9	6.0
France	4.5	4.5	3.7	7.3	7.1
Germany	1.6	1.4	1.3	1.7	3.0
Spain	2.1	4.4	2.9	3.4	2.5
Italy	19.3	12.4	11.2	16.7	15.9
Greece	1.3	1.8	1.0	1.4	2.0
Others	2.8	3.1	2.5	3.1	3.5
Total	39.7	34.9	29.4	40.5	41.7
USSR & Eastern Europe					
Hungary	0.1	0.4	0.3	0.6	1.2
Romania	0.0	0.6	0.3	0.8	1.5
USSR	0.0	0.1	0.0	0.6	0.8
Others	0.1	0.8	0.4	0.0	0.2
Total	0.2	2.0	1.0	2.0	6.6
Asia:					
Turkey	2.0	1.0	1.5	1.0	0.6
Iraq	1.3	2.3	1.2	0.4	0.0
Saudi Arabia	2.0	4.2	10.4	10.0	9.3
Japan	12.3	11.8	8.9	7.7	7.0
South Korea	1.0	1.0	0.7	0.6	0.7
Others	3.6	4.2	3.3	2.9	3.3
Total	22.6	24.4	26.0	22.6	20.9
Africa:					
South Africa	1.5	1.1	1.2	0.9	1.0
Egypt	0.8	0.8	0.8	0.4	0.4
Others	0.7	1.0	0.8	1.4	1.1
Total	3.0	2.9	2.7	2.7	2.5
Oceania:					
Australia	1.8	1.7	1.2	1.2	1.1
New Zealand	0.3	0.3	0.3	0.2	0.2
Others	0.1	0.0	0.0	0.1	0.0
Total	2.2	2.0	1.6	1.5	1.3
Total	100.0	100.0	100.0	100.0	100.0

1/ Totals may not add due to rounding.

Table 34--Import U.S. seeds for planting; region and country share, by value 1/

Region/country	1987	1988	1989	1990	1991
North and Central America:					
Canada	37.7	30.4	27.0	26.1	24.9
Mexico	2.0	2.1	3.0	3.4	3.8
Guatemala	2.5	2.4	2.3	2.7	2.5
Costa Rica	2.1	0.7	0.9	1.3	0.1
Others	0.1	0.1	0.0	0.0	0.1
Total	44.4	35.8	33.2	33.4	31.4
South America:					
Chile	4.0	6.8	13.3	11.2	10.7
Argentina	1.5	0.7	4.0	1.0	0.7
Others	0.5	0.8	0.4	0.1	0.3
Total	6.0	8.3	17.7	12.3	11.7
Western Europe:					
Denmark	2.1	1.9	1.5	1.4	1.2
United Kingdom	0.8	0.6	0.5	0.8	0.5
Netherlands	10.2	9.2	8.9	9.3	10.7
France	1.7	1.0	1.3	1.4	1.8
Germany	2.5	2.2	1.8	1.6	2.2
Italy	1.2	1.6	1.0	1.0	1.2
Others	0.7	0.3	1.4	0.1	0.5
Total	19.2	16.8	16.3	15.7	18.0
USSR & Eastern Europe:					
Hungary	0.0	1.2	3.1	0.7	0.1
Others	0.5	0.1	0.1	0.1	0.1
Total	0.5	1.3	3.1	0.7	0.1
Asia:					
India	2.9	7.5	3.5	3.1	5.2
Thailand	0.7	1.6	2.8	5.4	5.3
Taiwan	6.7	4.5	6.3	4.8	3.5
Japan	6.0	6.4	6.9	7.6	7.8
China(Mainland)	0.0	2.4	4.0	6.8	9.0
Others	3.1	2.0	1.5	2.9	0.5
Total	19.4	24.5	25.0	30.5	31.3
Africa:					
Ethopia	3.0	3.3	0.1	0.1	0.1
South Africa	0.1	0.5	0.0	0.0	0.0
Others	0.8	0.0	0.6	0.8	1.2
Total	3.9	3.8	0.7	0.9	1.3
Oceania:					
Australia	2.1	1.8	1.6	2.2	1.9
New Zealand	4.5	5.6	2.4	4.2	3.5
Total	6.5	7.4	4.0	6.4	0.1
Total	100.0	100.0	100.0	100.0	100.0

1/ Totals may not add due to rounding.

Total Imports

The value of total seed imports rose 12 percent to $165 million in 1991 compared to 1990. This increase largely reflects 32, 4, and 56 percent increases in vegetable, flower, and other seed imports, respectively. In 1991, U.S. net seed trade balance rose 15 percent to $507 million from 1990 (table 32).

In calendar year 1991, Canada continued to be the leading U.S. supplier of planting seeds, with 25 percent of total seed import value (table 34). Chile and the Netherlands, with 11 percent each, were the second largest sources. Mainland China supplied 9 percent.

Pesticides

Prices

Herbicide and insecticide prices have generally risen over the past 3 years (table 35). Pesticide manufacturers increased expenditures to research and develop new products

and to develop additional data to reregister older products. In addition, many pesticide manufacturers have embarked on expensive biotechnology research. Dealer costs also have risen, especially for liability insurance.

Average farm-level herbicide prices rose 2.4 percent between 1991 and 1992, after an 8.6 percent hike in 1990. Atrazine, a major corn and grain sorghum herbicide, showed the greatest increase -- 7.1 percent. Trifluralin, a major soybean and cotton herbicide, was second at 6.7 percent.

Farm-level insecticide prices were up 4.8 percent, compared with a jump of 13.0 percent last year. The price of methyl parathion (used extensively in cotton production for boll weevil control) was up 14.2 percent in 1992, following a 41 percent increase in 1991. The mild winter of 1991-92 indicated an upsurge in boll weevil pressure. Growers therefore stocked up on methyl parathion; tightening supplies and increasing the price.

Table 35--April farm pesticide prices 1/

Pesticides	1990	1991	1992	Change 91-92
	Dollars per pound 2/			Percent
Herbicides:				
Alachlor	5.70	6.15	6.35	3.3
Atrazine	2.93	3.25	3.48	7.1
Butylate	3.13	3.34	3.10	-7.2
Cyanazine	5.43	5.65	5.83	3.2
Metolachlor	6.94	7.49	7.69	2.7
Trifluralin	6.70	7.50	8.00	6.7
2,4-D	2.71	2.83	2.93	3.5
Composite 3/	4.64	5.04	5.16	2.4
Insecticides:				
Carbaryl	4.36	4.44	4.95	11.5
Carbofuran	9.77	10.39	10.84	4.3
Chlorpyrifos	9.65	10.65	11.30	6.1
Fonofos	9.52	6/ 10.30	10.20	-1.0
Methyl parathion 4/	2.94	4.15	4.74	14.2
Phorate	7.25	7.78	8.06	3.6
Pyrethroids 5/	50.00	56.54	62.50	10.5
Terbufos	10.52	11.28	11.25	-.3
Composite 3/	10.91	12.33	12.92	4.8

1/ Derived from the April survey of farm supply dealers conducted by NASS, USDA. 2/ Active ingredients. 3/ Includes above materials and other major materials but not products registered in the last 2 to 3 years. 4/ Supplied by Fred Cooke, Mississippi Agricultural Experiment Station. 5/ Average of fenvalerate and permethrin prices based on 2.6 pounds active ingredient per gallon. 6/ Revised.

Consumption

Total 1992 farm pesticide use on major field crops is projected at 487 million pounds active ingredients (a.i.), up 9 million from 1991 (table 36). June planted acreage for the 10 major field crops increased from 253 million in 1991 to 258 million in 1992. The area planted to row crops, which tend to be pesticide intensive, increased 4.2 million acres. Corn and soybeans accounted for 83 percent of herbicide consumption, corn and cotton 73 percent of insecticide consumption, and peanuts 80 percent of fungicide consumption in 1992.

Table 36--Projected pesticide use on major U.S. field crops, 1992

Crops	June 1 planted acres	Herbicides	Insecticides	Fungicides
	Million	Million pounds (a.i.)		
Row:				
Corn	79.3	235.9	29.2	0.07
Cotton	13.3	20.3	19.8	0.21
Grain sorghum	12.4	11.8	1.9	0.00
Peanuts	1.8	6.6	1.4	6.48
Soybeans	59.0	104.2	9.1	0.06
Tobacco	0.8	1.3	3.0	0.40
Total	166.6	380.1	64.4	7.22
Small grains:				
Barley and oats	15.9	4.0	0.1	0.00
Rice	3.0	12.7	0.5	0.07
Wheat	72.3	15.1	2.0	0.83
Total	91.2	31.8	2.6	0.88
1992 total	257.8	411.9	67.0	8.12
1991 total	252.9	402.7	66.5	8.85

Pesticide Use on 1991 Fall Potatoes

Fall potatoes are grown across the northern United States, from Maine to Washington. Herbicides were applied to 79 percent of the fall potato acreage in the 11 surveyed states (table 37). However, in Minnesota and North Dakota, where rainfall is low, only 45 to 50 percent of the acreage is treated with herbicides. Insecticide use was fairly uniform across all states (table 38). The proportion of acreage treated with fungicides was highest in the humid eastern states and lowest in the more arid western states (table 39).

Herbicides were applied once on 55 percent of the fall potato acreage, and twice on 20 percent. Insecticide treatments averaged 2.1, ranging from 1.2-1.3 in Colorado and Idaho to 4.6 in New York. Fungicide treatments were highest in Maine at 6.0, followed by Wisconsin at 5.9.

Herbicides

Metribuzin was the most commonly used herbicide in fall potato production (table 37). It was either used alone or in combination with other herbicides to broaden the weed control spectrum. Metribuzin requires moisture, shortly after treatment, to be effective. A large share of the fall potatoes in the Pacific Northwest is treated with metribuzin because most of the crop is irrigated. Metribuzin, generally applied after planting but before potatoes emerge, controls such weeds as foxtail, ragweed, pigweed, and mustard.

EPTC was the second most commonly used herbicide. It is a selective herbicide that can be applied preplant or after planting prior to weed germination. It controls pigweed, foxtail, and wild oats. EPTC must be incorporated into the soil because it is readily lost by volatilization. It is most effective where rainfall is low, and is more often used in arid areas.

Insecticides

Colorado potato beetles, aphids, and leafhoppers constitute the major insect problems in potato production. The Colo-

Table 37--Selected herbicides used in fall potato production, 1991 1/

Item	CO	ID	ME	MI	MN	NY 2/	ND	OR	PA	WA	WI	Area
1,000 acres planted	71	395	81	35	70	23	155	53	21	144	68	1116
1,000 acres treated with herbicides	46	364	80	30	31	23	73	38	18	117	64	884
Percent of planted acres treated:	65	92	99	86	45	100	47	72	85	81	94	79
With 1 treatment	44	57	94	54	35	73	31	52	65	65	64	55
With 2 treatments	21	29	4	25	9	27	12	15	17	13	24	20
With 3 treatments	nr	6	1	3	1	nr	4	3	nr	3	2	4
With 4 treatments	nr	nr	nr	4	nr	nr	nr	2	3	nr	4	*
Average times applied	1.33	1.45	1.07	1.53	1.14	1.27	1.42	1.37	1.32	1.25	1.41	1.36
1,000 acre-treatments 3/	61	528	86	46	36	29	104	53	24	146	91	1204
Acre-treatments by active ingredient: 4/						Percent						
Single materials--												
EPTC	23	24	1	1	20	3	15	22	4	28	5	19
Glyphosate	nr	nr	2	5	nr	5	3	3	7	1	6	1
Linuron	nr	nr	19	17	2	24	nr	nr	6	nr	8	3
Metolachlor	5	*	1	7	16	11	7	8	2	nr	3	3
Metribuzin	26	46	70	34	17	5	8	20	19	26	44	37
Pendimethalin	nr	4	1	1	7	nr	28	4	nr	1	1	5
Sethoxydin	2	*	3	2	7	3	6	2	3	nr	7	2
Trifluralin	nr	1	nr	nr	5	nr	6	1	nr	4	nr	2
Other	2	nr	nr	nr	nr	nr	nr	2	1	1	1	*
Combination mixes--												
Metolachlor + linuron	nr	nr	nr	11	nr	11	nr	nr	13	nr	nr	1
Metribuzin + EPTC	30	9	nr	nr	nr	nr	nr	7	nr	5	nr	7
Metribuzin + metolachlor	7	2	3	7	14	16	4	11	38	nr	15	5
Metribuzin + pendimethalin	nr	6	nr	nr	7	5	14	7	2	14	10	7
Trifluralin + EPTC	nr	2	nr	nr	nr	nr	nr	1	nr	8	nr	2
Other	nr	5	1	16	4	18	6	13	5	12	1	6
Total	100	100	100	100	100	100	100	100	100	100	100	100

nr = None reported. * = Less than 1 percent.

1/ Preliminary. 2/ Excludes Long Island. 3/ Acres treated x times applied. 4/ Spot treatments not included.

Table 38--Selected insecticides used in fall potato production, 1991 1/

Item	CO	ID	ME	MI	MN	NY 2/	ND	OR	PA	WA	WI	Area
1,000 acres planted	71	395	81	35	70	23	155	53	21	144	68	1116
1,000 acres treated with insecticides	43	362	78	34	70	23	145	46	21	136	64	1022
Percent of planted acres treated:	61	92	97	96	100	100	93	88	99	94	94	92
With 1 treatment	50	63	11	20	28	nr	34	24	11	19	14	38
With 2 treatments	8	27	27	9	36	17	30	19	8	41	27	27
With 3 treatments	3	2	26	27	25	17	20	17	20	21	24	14
With 4 treatments	nr	nr	20	15	10	13	9	24	26	8	11	7
With 5 treatments	nr	nr	3	6	nr	3	nr	3	9	2	14	2
With 6 or more	nr	nr	10	19	1	50	nr	1	25	3	4	4
Average times applied 3/	1.23	1.33	3.07	3.68	2.19	4.63	2.05	2.62	3.76	2.39	2.88	2.12
1,000 acre-treatments	53	481	240	124	153	107	297	121	78	324	185	2164
Acre-treatments by active ingredient: 4/ 5/						Percent						
Single materials--												
Azinphos-methyl	nr	1	19	12	2	1	5	1	4	2	nr	4
Carbofuran	nr	1	nr	5	21	nr	40	nr	1	*	4	8
Disulfoton	6	1	3	nr	nr	3	nr	7	1	16	4	4
Endosulfan	8	1	18	3	13	4	6	*	3	nr	15	6
Esvenvalerate	67	25	23	7	22	6	10	1	5	1	22	16
Ethoprop	nr	13	1	3	nr	nr	nr	8	nr	2	nr	4
Methamidphos	12	5	15	11	1	15	2	48	5	39	14	15
Permethrin	4	9	2	2	1	9	nr	6	4	4	16	5
Phorate	nr	36	*	10	23	nr	17	18	10	15	7	17
Phosphamidon	nr	nr	nr	nr	16	nr	12	nr	nr	1	nr	3
Other	2	4	12	17	1	35	4	7	19	11	14	10
All combination mixes	nr	3	7	30	nr	27	2	5	48	10	4	9
Total	100	100	100	100	100	100	100	100	100	100	100	100

* = Less than 1 percent. nr = None reported.

1/ Preliminary. 2/ Excludes Long Island. 3/ Acres treated x times applied. 4/ Spot treatments not included. 5/ Data were not tabulated to reveal insecticide-fungicide combination mixes.

rado potato beetle has developed some resistance to a number of organophosphorus insecticides, and to some of the newer synthetic pyrethroids.

The most commonly used insecticides across all states are esfenvalerate, methamidophos, and phorate (table 38). Carbofuran and phosphamidon are used extensively in Minnesota and North Dakota. Carbofuran, a systemic, is generally applied at planting for flea beetle and early-season Colorado potato beetle control. Phosphamidon, an organophosphate, is still effective against the Colorado potato beetle and is inexpensive to use.

Fungicides

Mancozeb, maneb, and chlorothalonil are the most commonly used fungicides in fall potato production (table 39). Early and late blight are the two most serious diseases.

Early blight kills the potato vine, reducing the food supply available for tuber production in the hill. Late blight kills the vine, and can also infect developed tubers, making them vulnerable to decay in storage. The disease organism is harbored in volunteer potato plants and in decaying vines and tubers left in the field. The disease organism contaminates the potato plant when rain splashes infected soil particles onto the foliage.

Mancozeb, maneb, and chlorothalonil are protective fungicides in that they must kill the disease organism before it invades the foliage. This explains the large number of fungicide treatments in high rainfall areas.

Herbicides on Winter Wheat

In 1992, herbicides were used on 33 percent of harvested winter wheat acreage in the surveyed states (table 40). In the Pacific Northwest (ID, WA, and OR), 80 to 96 percent of the winter wheat acreage was treated with herbicides in order to control annual broadleaf and grass weeds during mild periods in the winter. In Montana and South Dakota, the proportion treated was about 50 percent. Winterkill thins wheat stands in these two states and invading weeds must be controlled to prevent additional yield losses.

Chlorsulfuron and 2,4-D were the two most commonly used herbicides. Chlorsulfuron, registered in 1982, controls broadleaf and grass weeds and can be applied either pre- or postemergence. In contrast, 2,4-D controls only broadleaf weeds and is applied postemergence. Chlorsulfuron gained rapidly in popularity and by 1988 accounted for 49 percent of the winter wheat herbicide acre-treatments but by 1992 dropped to 26 percent. The reason is that weeds resistant to chlorsulfuron have been identified (kochia and Russian thistle) and farmers have been urged to rotate chlorsulfuron with other herbicides to slow resistance in other weed species.

Table 39--Selected fungicides used in fall potato production, 1991 1/

Item	CO	ID	NE	MI	MN	NY 2/	ND	OR	PA	WA	WI	Area
1,000 acres planted	71	395	81	35	70	23	155	53	21	144	68	1116
1,000 acres treated with fungicides	66	147	79	31	53	23	145	35	18	100	66	763
Percent of planted acres treated:	92	37	98	87	76	100	93	66	88	69	97	68
With 1 treatment	37	33	6	8	26	7	45	26	16	23	7	27
With 2 treatments	21	2	5	20	22	13	26	11	10	26	1	11
With 3 treatments	32	2	1	8	7	7	10	12	11	10	6	8
With 4 treatments	2	nr	1	23	7	27	11	15	8	5	5	5
With 5 treatments	nr	nr	3	5	10	3	1	2	9	3	11	3
With 6 treatments	nr	nr	5	7	1	30	nr	nr	6	1	20	3
With 7 treatments	nr	nr	15	0	2	7	nr	nr	15	1	11	3
With 8 treatments	nr	nr	16	2	nr	nr	nr	nr	6	nr	11	2
With 9 treatments	nr	nr	18	1	1	3	nr	nr	nr	nr	10	2
With 10 or more	nr	nr	20	5	nr	3	nr	nr	7	nr	15	4
Average times applied	1.97	1.17	6.04	3.69	2.60	4.33	1.91	2.26	3.82	2.21	5.90	2.84
1,000 acre-treatments 3/	129	172	479	113	138	100	276	79	70	221	390	2167
Acre-treatments by active ingredient: 4/ 5/	Percent											
Single materials--												
Chlorothalonil	16	52	5	3	25	1	nr	35	6	9	7	12
Iprodione	nr	2	nr	nr	nr	nr	nr	9	nr	19	nr	2
Mancozeb	11	23	47	64	35	46	41	7	70	22	46	39
Maneb 6/	3	10	36	6	21	28	21	15	6	9	14	19
Metiram	nr	nr	nr	7	nr	4	nr	nr	nr	5	nr	1
Triphenyltin hydroxide	49	nr	*	nr	10	1	23	1	nr	nr	4	7
Other	18	10	*	1	nr	nr	1	20	1	24	*	5
Combination mixes--												
Mancozeb + metalaxyl	nr	nr	7	3	nr	16	nr	5	14	6	2	4
Other	4	3	4	16	9	3	15	7	4	6	26	11
Total	100	100	100	100	100	100	100	100	100	ERR	100	100

* = Less than 1 percent. nr = None reported.

1/ Preliminary. 2/ Excludes Long Island. 3/ Acres treated x times applied. 4/ Spot treatments not included. 5/ Data were not tabulated to reveal insecticide-fungicide combination mixes. 6/ Includes maneb + zinc.

Table 40--Selected herbicides used in winter wheat production, 1992 1/

Item	AR	CO	ID	IL	IN	KS	MO	MT	NE	OH	OK	OR	SD	TX	WA	Area
1,000 acres harvested	900	2300	800	1100	450	10900	1350	2250	1950	1140	6000	850	1200	3800	2000	36990
1,000 acres treated with herbicides	174	564	638	143	101	2725	37	1182	633	117	2238	818	564	518	1852	12303
Percent of harvested acres treated:	19	25	80	13	22	25	3	53	32	10	37	96	47	14	93	33
With 1 treatment	16	22	64	13	22	24	3	44	28	10	35	64	45	14	75	30
With 2 or more	3	3	16	*	*	1	*	9	4	*	2	32	2	*	18	3
Average times applied	1.25	1.09	1.25	1.00	1.00	1.05	1.00	1.16	1.14	1.00	1.04	1.46	1.04	1.00	1.21	1.13
1,000 acre-treatments 2/	218	613	797	143	101	2864	37	1369	723	117	2335	1193	587	518	2233	13844
Acre-treatments by active ingredient: 3/								Percent								
Single materials--																
2,4-D	54	29	25	13	35	15	50	35	23	74	12	7	8	19	14	18
Chlorsulfuron	nr	nr	nr	nr	nr	62	nr	nr	6	nr	72	2	4	9	2	26
Dicamba	nr	13	1	nr	nr	nr	nr	2	12	nr	nr	3	nr	4	1	2
MCPA	nr	nr	3	nr	23	1	nr	nr	nr	nr	nr	3	nr	17	1	2
Metsulfuron	nr	13	2	nr	nr	1	nr	2	24	nr	1	nr	nr	27	nr	4
Other	13	nr	10	nr	nr	nr	nr	12	6	13	1	23	8	4	16	8
Combination mixes--																
2,4-D + chlorsulfuron	nr	nr	nr	nr	nr	1	nr	2	nr	nr	4	6	nr	nr	nr	2
2,4-D + dicamba	nr	nr	3	nr	8	4	nr	17	3	13	nr	3	nr	nr	6	4
2,4-D + glyphosate	nr	nr	nr	nr	nr	1	nr	nr	3	nr	1	nr	nr	11	nr	1
2,4-D + metsulfuron	nr	36	nr	nr	nr	1	nr	12	16	nr	nr	nr	58	8	nr	7
Thifensulfuron + tribenuron	29	nr	1	87	35	nr	50	2	nr	nr	nr	3	4	nr	5	3
Other 2-way mixes	nr	9	20	nr	nr	12	nr	13	6	nr	5	14	14	nr	14	11
3-way mixes	3	nr	16	nr	nr	nr	nr	4	nr	nr	1	29	4	nr	33	10
4-way mixes	nr	nr	18	nr	nr	nr	nr	nr	nr	nr	nr	7	nr	nr	9	3
	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

nr = None reported.

1/ Preliminary. 2/ Acres treated x times applied. 3/ Spot treatments not included.

Peanut Production Practices and Input Use - 1991

by

Herman Delvo, Mohinder Gill, Harold Taylor, and Len Bull [1/]

Abstract: This article presents information on the application of agricultural inputs to 1991 peanut production. Peanut production, yields, and diseases are highly sensitive to cropping patterns. Therefore, input levels vary in relation to the crop grown previously in the cropping sequence.

Keywords: Peanut production, input use, cropping patterns, tillage system, seed, fertilizer, pesticide.

The information presented on production practices and application of agricultural inputs on peanuts for 1991 was obtained from survey data collected in the major producing States of Georgia, Texas, North Carolina, and Virginia. These States planted 71 percent of the total U.S. peanut acres. The survey was in response to rising concern about food safety and possible contamination of ground water through agricultural input uses, tillage practices, and cropping patterns.

Peanuts are normally a highly profitable crop (1, 2). In addition, supplies are stabilized and production is protected bythe 1990 Farm Bill through support prices, marketing quotas, and import quotas. Peanut support prices are linked to production costs, so input levels are extremely important economic considerations.

Cropping sequence is an important part of economical peanut production. Peanuts following peanuts or soybeans tend to have lower yields due to soil-borne diseases and nematodes. Also, good weed control in the preceding crop will help reduce weed populations in peanuts. Many troublesome broadleaf weeds that can be readily controlled in grass crops (such as corn, sorghum, or a perennial grass) are difficult to chemically control in peanuts.

The peanut crop is also very effective in using residual fertility. The peanut plant is deep-rooted, the taproot can penetrate to a depth of 6 feet. Therefore, a well fertilized preceding crop (such as corn) will more effectively provide nutrients to the peanuts than direct fertilizer applications.

Cropping Patterns

The 1991 Economic Research Service cropping practices survey found that the crops commonly rotated with peanuts are corn, cotton, and small grains. In the four major peanut producing States, the three most common cropping patterns were: continuous peanuts; peanuts-corn-peanuts; and fallow-fallow-peanuts. These three cropping sequences were used on 35 percent of the 1991 peanut acreage in these States (table A1).

Continuous peanuts was most common in Texas (47 percent), and Georgia (10 percent). Twenty-three percent of 1991 peanut acreage grew peanuts in the preceding year. The sequence of peanuts following peanuts has some disadvantages because this can result in yield losses due to white mold, leaf spot, and other peanut diseases.

The peanuts-corn-peanuts sequence was predominant in Virginia with 38 percent, followed by North Carolina (17 percent), and Georgia (10 percent). For all surveyed States, 30

Table A1--Peanut cropping patterns, 1991

Previous crop 1990	1989	GA	NC	TX	VA	1991 Area
Planted acres (1,000) 1/		870	165	315	96	1,446
		Percent				
Corn	Corn	9	6	nr	14	7
Corn	Soybean	6	12	nr	8	5
Corn	Fallow 2/	4	1	nr	1	3
Corn	Cotton	2	12	nr	nr	2
Corn	Peanut	10	17	3	38	11
Corn	Other	1	8	nr	1	1
Soybean	Soybean	3	nr	nr	nr	2
Soybean	Peanut	1	2	nr	13	2
Soybean	Other	2	1	*	1	2
Fallow 2/	Fallow	9	1	12	1	8
Fallow	Peanuts	5	nr	6	6	5
Fallow	Soybean	3	1	nr	nr	2
Fallow	Corn	2	5	1	nr	2
Fallow	Other	2	nr	1	nr	1
Cotton	Corn	2	14	nr	nr	3
Cotton	Cotton	6	2	8	nr	5
Cotton	Peanut	4	8	1	3	4
Cotton	Other	2	2	nr	nr	2
Peanut	Peanut	10	nr	47	3	16
Peanut	Fallow	3	nr	3	3	3
Peanut	Soybean	3	nr	nr	nr	2
Peanut	Other	3	nr	2	3	2
Other	Other	[illegible]	8	18	5	10
Total		100	100	100	100	100

nr = None reported. * = Less than 1 percent.
1/ Preliminary. 2/ No crops planted during this year.

1/ The authors are agricultural economists with the ResourcesTechnology Division, Economic Research Service, USDA.

percent of 1991 peanut land grew corn in 1990, and other crops such as soybeans, cotton, and corn in 1989. The peanut crop can effectively use any residual soil fertility remaining from corn fertilization.

The practice leaving land fallow preceding peanuts is popular in Texas and Georgia. Peanuts were grown on 18 percent of 1991 acreage following fallow. To grow peanuts on idle land helps reduce weed competition, provided that weeds in the fallow period are adequately controlled (2).

Tillage Systems

Peanuts are typically planted in soils prepared by conventional tillage systems which leave very little previous crop residue on the soil surface (table A2). The moldboard plow was used on 86 percent of the 1991 peanut acreage in the four surveyed States. This varied from 96 percent in Georgia to only 64 percent in Texas. Virginia and Texas also appear to be experimenting with conservation tillage, including some no-tillage systems. These conservation tillage systems left an average of 40 percent or more residue cover.

Table A2--Tillage systems used in peanut production, 1991

Category	GA	NC	TX	VA	Area
	Peanut				
Planted acres (1,000) 1/	870	165	315	96	1,446
	% of acres 2/				
Tillage system:					
Conv/w mbd plow 3/	96	80	64	73	86
Conv/wo mbd plow 4/	3	19	27	8	10
Mulch-till 5/	id	id	2	11	2
No-till 6/	nr	nr	7	8	2
Residue remaining after planting:	Percent % of soil surface covered				
Conv/w mbd plow	1	*	*	*	1
Conv/wo mbd plow	7	2	5	10	5
Mulch-till	id	id	39	50	46
No-till	nr	nr	64	81	68
Average	2	1	7	13	3
	Number				
Hours per acre:					
Conv/w mbd plow	.9	1.2	.5	1.1	.9
Conv/wo mbd plow	.9	1.0	.8	.7	.8
Mulch-till	id	id	.3	.4	.3
No-till	nr	nr	.1	.3	.2
Average	.9	1.2	.7	.9	.9
Times over field:					
Conv/w mbd plow	4.7	6.1	5.6	5.2	5.1
Conv/wo mbd plow	4.9	6.2	5.0	4.1	5.2
Mulch-till	id	id	1.5	2.3	2.1
No-till	nr	nr	1.0	1.7	1.2
Average	4.7	6.1	5.0	4.5	4.9

id = Insufficient data. nr = none reported.
* = less than 1 percent.

1/ Preliminary. 2/ May not add to 100 due to rounding. 3/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 4/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow. 5/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system. 6/ No-tillage--no residue-incorporating tillage operations performed prior to planting; allows passes of non-tillage implements, such as stalk choppers.

There are tillage differences between Virginia and North Carolina even though the production areas are contiguous and quite similar. These differences can be explained by the production emphases taken by each State's producers and extension/research groups. The Virginia producers are emphasizing corn production in rotation with peanuts. This is reflected by the increased incidence of conservation tillage methods used in Virginia. North Carolina, on the other hand, is emphasizing the production of peanuts as a main cash crop. Its tillage methods reflect the emphasis on seedbed preparation for peanuts.

The time required for tillage operations in peanut production is closely related to the number of trips across the field. Conventional tillage systems average about five to six trips and around 1 hour per acre. Conservation tillage systems average about two trips for mulch tillage and one trip for no tillage. This results in an average time required of less than a third of an hour per acre.

Seeds

To ensure high yields and high-quality peanuts, producers generally use certified seeds. These are disease free and are of known pedigree, purity, and quality. Certified seeds are grown under strict regulations and close supervision. They are typically grown on well-drained light sandy loam soils; grown over a moderately long period of 4 to 5 months; and with a steady, rather high temperature and a uniformly distributed supply of moderate moisture.

The average seeding rate for the surveyed States in 1991 was 91 pounds per acre (table A3). However, peanut seeding rates among States vary significantly due to the type or variety of the seed (large or small), row pattern, and percent germination. For example, Runner and Spanish types (small sized seeds) average 4 to 6 seeds per foot with 90 percent germination. Virginia types (larger and heavier seeds) average 3 to 4 seeds per foot and result in a higher seeding rate measured in pounds per acre (1). Virginia and North Carolina had the higher seeding rates, 111 pounds and 110 pounds, respectively, because of the larger seed size and weight. Georgia and Texas, on the other hand, had the lower seeding rates because of differences in variety, soil, moisture, and other factors.

Seeding rates and seed prices determine seed cost per acre. In 1991, the average seed cost per acre was $109.26. Georgia had lower seeding rate per acre but higher seed cost than Virginia, reflecting higher peanut seed price. Average seed

Table A3--Peanuts seed rates, seed cost per acre, and percent seed purchased, 1991 1/

States	Acres planted	Rate per acre	Cost per acre 3/	Acres with purchased seed
	Thousand	Pounds	Dollars	Percent
Georgia	870	93	115.31	95
North Carolina	165	110	118.23	89
Texas	315	70	87.98	98
Virginia	96	111	113.56	66
1991 average 2/	1,446	91	109.26	93

1/ States planted 71 percent of U.S. peanuts acres in 1991. 2/ Preliminary. 3/ Based on data from farmers who used purchased seed.

cost per acre in 1992 is likely to be much lower than in 1991, because average seed price fell 37 percent in 1992.

Farmers in the surveyed States used purchased rather than home-grown seed on 93 percent of the 1991 peanut acres. Difference in seed cost and yield often determine the choice between purchased and home-grown seed.

Table A4--Fertilizer use on peanuts, 1991

State	Acres planted 1/	Fields in survey	Acres receiving: Any ferti-lizer	N	P205	K20	Application rates: N	P205	K20	Proportion fertilized: At or before seeding	After seeding	Both
	1,000	No.	Percent				Pounds per acre			Percent		
Georgia	870	259	87	71	86	86	17	45	73	98	1	1
North Carolina	165	84	80	52	65	80	16	40	65	100	0	0
Texas	315	232	82	82	76	65	39	42	35	84	7	9
Virginia	96	88	55	46	48	53	22	57	112	100	0	0
Area	1,446	663	83	69	79	79	22	44	69	95	2	3

1/ Preliminary.

Table A5--Selected herbicides used in fall peanut production, 1991 1/

Item	GA	NC-VA	TX	Area	GA	NC-VA	TX	Area
1,000 acres planted	870	261	315	1446				
1,000 acres treated with herbicides	856	253	289	1398				
Percent of planted acres treated:	98	97	92	97				
With 1 treatment	14	14	57	24				
With 2 treatments	37	22	23	31				
With 3 treatments	30	31	5	25				
With 4 treatments	10	23	7	12				
With 5 or more treatments	7	7	nr	5				
Average times applied	2.60	2.88	1.58	2.44				
1,000 acre-treatments 2/	2224	731	456	3411				
Acre-treatments by active ingredient: 3/	Percent				Average a.i. rate per acre per treatment			
Single materials--								
2,4-DB	15	12	10	14	0.24	0.22	0.29	0.24
Benefin	5	1	4	4	0.98	1.22	0.96	0.98
Bentazon	3	1	3	2	0.57	0.89	0.68	0.61
Chlorimuron-ethyl	6	nr	nr	4	0.01			0.01
Ethalfluralin	9	2	3	7	0.71	0.57	0.68	0.70
Metolachlor	3	27	14	9	1.49	1.78	1.24	1.62
Paraquat	9	3	nr	7	0.18	0.14		0.18
Pendimethalin	5	4	16	7	0.93	0.81	0.64	0.82
Sethoxydim	5	7	3	5	0.22	0.20	0.19	0.21
Trifluralin	*	nr	21	3	0.50		0.47	0.48
Vernolate	*	5	nr	1	1.17	2.25		2.00
Other single	2	4	10	3	1.32	0.71	0.39	0.77
Combination mixes--								
2,4-DB/Paraquat	2	*	nr	2	0.21 / 0.17	0.25 / 0.21		0.21 / 0.17
Bentazon/Acifluorfen	*	11	nr	3	0.42 / 0.21	0.46 / 0.23		0.46 / 0.23
Bentazon/Paraquat	12	2	nr	8	0.46 / 0.14	0.50 / 0.13		0.46 / 0.14
Benefin/Metolachlor	1	2	*	1	1.13 / 1.50	0.80 / 2.13	0.38 / 0.50	0.99 / 1.69
Metolachlor/Ethalfluralin	5	3	nr	4	1.68 / 0.73	1.50 / 0.50		1.64 / 0.68
Pendimethalin/Metolachlor	2	3	1	2	1.04 / 2.00	0.65 / 1.53	0.50 / 1.10	0.89 / 1.80
Vernolate/Benefin	2	2	*	2	1.73 / 0.95	2.02 / 1.15	0.70 / 0.56	1.76 / 0.98
Vernolate/Ethalfluralin	5	*	nr	3	1.78 / 0.79	1.95 / 0.81		1.78 / 0.79
Vernolate/Pendimethalin	1	1	4	2	1.56 / 0.93	1.72 / 0.83	1.75 / 0.50	1.66 / 0.76
Other 2-way combinations	4	6	9	5	1.05	2.05	1.46	1.40
3-way combination mixes	3	4	1	3	1.08	1.40	1.05	1.18
All applications	100	100	100	100	0.87	1.27	0.79	0.95

nr = None reported. * = Less than 1 percent.

1/ Preliminary. 2/ Acres treated x times applied. 3/ Spot treatments not included.

Fertilizer

Fertilizers used on peanuts are primarily for maintenance since these deep-rooted plants respond better to residual fertilizer than to direct applications. Optimum peanut soil fertility is achieved primarily through fertilization programs designed for other crops grown in rotation (1). Therefore, the fertilization practices for the crop immediately preceding peanuts are extremely important. Growers are encouraged to use soil tests to develop a history of nutrient levels for their total cropping system to avoid fertility problems that may reduce peanut yield and quality (2).

Fertilizer, at least at a supplemental level, was applied on 83 percent of the peanut acreage in the four-state area for 1991 (table A4). The proportion of acres treated with the various nutrients ranged from 69 percent for nitrogen to 79 percent for phosphate and potash. Georgia had the most acres treated with phosphate and potash at 86 percent, while Texas had the most for nitrogen at 82 percent.

Application rates for the area were 22 pounds per acre for nitrogen, 44 for phosphate, and 69 for potash. On a per acre basis, Texas had the highest nitrogen rate, 39 pounds, while Virginia had the most for phosphate and potash, 57 and 112 pounds per acre, respectively.

Ninety-five percent of the fertilizer was applied at or before seeding for the area. In North Carolina and Virginia, all fertilizer was applied at or before seeding while Texas applied 84 percent at or before seeding and 7 percent after seeding. Nine percent of Texas' acres received fertilizer before, at, and after seeding.

Pesticide Use

Herbicides were applied to 97 percent of the peanut acreage in the four surveyed States in 1991 (table A5). On average, 2.4 herbicide applications were made during the growing season, ranging from 2.9 treatments in North Carolina-Virginia (NC-VA) to 1.6 in Texas. Mechanical cultivation was used to control weeds on 90 percent of the peanut acreage (table A6). The average number of cultivations was 1.9 times, ranging from 2.2 in Texas to 1.6 in NC-VA. Insecticides were applied to 56 percent of the peanut acreage (table A7). NC-VA growers treated 94 percent of their acreage compared to only 24 percent in Texas. The average number of insecticide treatments ranged from 1.5 to 2.0 per season in these States. Peanut growers treated 89 percent of their acreage with fungicides in 1991 (table A8). However, in the more humid Southeast, growers treated 97 percent of the

Table A6--Weed control cultivations used in peanut production, 1991 1/

Item	GA	NC-VA	TX	Area
1,000 acres planted	870	261	315	1446
1,000 acres cultivated	788	206	307	1300
Percent of planted acres cultivated:	91	79	97	90
With 1 cultivation	28	43	23	30
With 2 cultivations	48	27	41	42
With 3 cultivations	13	9	26	15
With 4 or more cultivations	2	nr	7	3
Average times cultivated	1.87	1.57	2.23	1.91

nr = None reported.

1/ Preliminary.

Table A7--Selected insecticides used in peanut production, 1991 1/

Item	GA	NC-VA	TX	Area	GA	NC-VA	TX	Area
1,000 acres planted	870	261	315	1446				
1,000 acres treated with insecticides	494	246	76	816				
Percent of planted acres treated:	57	94	24	56				
With 1 treatment	34	28	15	29				
With 2 treatments	15	43	6	18				
With 3 treatments	6	18	3	7				
With 4 or more treatments	2	5	nr	2				
Average times applied	1.63	2.00	1.52	1.73				
1,000 acre-treatments 2/	806	493	115	1414				
					Average a.i. rate			
Acre-treatments by active ingredient: 3/	Percent				per acre per treatment			
Single materials--								
Acephate	2	1	24	3	0.83	0.51	0.41	0.55
Aldicarb	34	33	26	33	1.01	1.11	0.83	1.03
Carbaryl	5	4	11	5	0.94	1.00	1.05	0.98
Chlorpyrifos	15	24	9	18	1.86	1.76	1.41	1.79
Esfenvalerate	9	13	4	10	0.03	0.03	0.01	0.03
Fonofos	2	2	9	3	2.38	1.99	1.16	1.93
Methomyl	18	9	1	14	0.36	0.41	0.37	0.37
Phorate	8	8	nr	7	1.04	1.12	nr	1.07
Other single	6	4	16	6	2.28	1.50	1.12	1.84
2-way combination mixes	1	2	nr	1	2.02	5.02	nr	3.79
All applications	100	100	100	100	1.04	1.16	0.85	1.07

nr = None reported. * = Less than 1 percent.

1/ Preliminary. 2/ Acres treated x times applied. 3/ Spot treatments not included.

acreage compared to 63 percent in Texas. The number of treatments per season ranged from 5.6 in Georgia to 2.0 in Texas.

Herbicides

Growers use a variety of herbicides, reporting 12 different active ingredients, for weed control in peanut production. Herbicide applications may be made preplant incorporated, preemergence, at-cracking, or postemergence. The particular active ingredient used and the timing of the application is influenced by the weed species present and the intensity of the infestation.

The most commonly used herbicide in peanut production, was 2,4-DB, accounting for 15 percent of the acre-treatments (table A5). It is used primarily to control cocklebur and several morning-glory species. It can be used from 2 weeks after planting up to 45 days before harvest. Treatments should be made when the weeds are small, 1 to 2 inches, however if environmental conditions prevent application at this stage, 2,4-DB will still control the growth of larger weeds. A second application of 2,4-DB can be made about 30 days later to control late germinating weeds.

Georgia growers used ethalfluralin, benefin, and pendimethalin as single active ingredients and in combination mixes with vernolate. These three materials are applied preplant incorporated. They control broadleaf signalgrass, crabgrass, fall and Texas panicum, foxtails, and goosegrass. Vernolate controls yellow and purple nutsedge. Paraquat and a mixture of bentazon plus paraquat were used postemergence. Paraquat is a non-selective material that will control small annual grasses and most small broadleaf weeds less than 1 inch in height. Bentazon controls cocklebur, jimsonweed, and smartweed.

NC-VA growers used metolachlor preemergence and bentazon plus acifluorfen postemergence. Metolachlor controls most annual grasses and pigweed. It also controls light infestations of yellow nutsedge. Acifluorfen in combination with bentazon broadens the weed control spectrum to include morning-glories, common ragweed, pigweed, and lambsquarter.

Trifluralin is the most commonly used herbicide by Texas peanut growers. It can be applied preplant, at planting, or postplant. It must be incorporated into the soil and kills the weed seedlings as they germinate. It controls a wide spectrum of broadleaf weeds and grasses. Pendimethalin is applied preplant incorporated and metolachlor preemergence. Very few postemergence herbicide applications are made indicating that growers generally get good weed control with only one application.

Insecticides

Aldicarb was the most commonly used insecticide, accounting for 33 percent of the acre-treatments in the surveyed States. It is applied at-planting as an in-furrow treatment. Aldicarb is a systemic insecticide that is taken up by the plant and provides early season protection from sucking in-

Table A8--Selected fungicides used in peanut production, 1991 1/

Item	GA	NC-VA	TX	Area	----GA---	--NC-VA--	----TX---	---Area---
1,000 acres planted	870	261	315	1446				
1,000 acres treated with fungicides	843	253	198	1294				
Percent of planted acres treated:	97	97	63	89				
With 1 treatment	5	16	35	13				
With 2 treatments	1	15	12	6				
With 3 treatments	2	23	6	7				
With 4 treatments	10	30	6	13				
With 5 treatment	27	12	2	19				
With 6 treatments	26	1	nr	16				
With 7 treatments	18	nr	2	11				
With 8 or more treatments	8	nr	nr	4				
Average times applied	5.56	3.11	2.00	4.53				
1,000 acre-treatments 2/	4685	786	396	5867				
Acre-treatments by active ingredient: 3/	------ Percent ------				---Average a.i. rate per acre per treatment--			
Single materials--								
Chlorothalonil	82	62	68	78	1.01	1.05	0.98	1.01
Copper hydroxide	nr	7	nr	1		1.16		1.16
Other single	2	6	14	3	1.81	0.79	0.91	1.29
Combination mixes--								
Chlorothalonil/Sulfur	16	9	9	14	0.92/1.54	1.03/1.46	0.46/0.66	0.91/1.49
Copper hydroxide/Sulfur	nr	9	nr	1		0.91/0.80		0.91/0.80
Other 2-way combination mixes	1	5	3	2	1.29	1.79	1.25	1.49
3-way combination mixes	*	1	*	*	2.83	3.28	1.46	2.90
All applications	100	100	100	100	1.26	1.29	1.01	1.25

nr = None reported. * = Less than 1 percent.

1/ Preliminary. 2/ Acres treated x times applied. 3/ Spot treatments not included.

sects such as aphids, thrips, and leafhoppers. This eliminates early season foliar insecticide sprays. In addition, it controls nematodes in the root zone.

Chlorpyrifos was the second most commonly used insecticide with a majority of the acre-treatments in Georgia and NC-VA. It is generally applied during early pegging in a band over the fruiting zone to control southern corn rootworm larvae and lesser cornstalk borer. Esfenvalerate and methomyl were used by Georgia and NC-VA growers while Texas growers used acephate and carbaryl to control foliage feeding insects such as beet armyworm, corn earworm, fall armyworm, green cloverworm, and velvetbean caterpillar.

Fungicides

Important factors in reducing the carryover of soil-borne inoculum are crop rotation and the burial of peanut residues by deep plowing or other cultivation practices. In 1991, about 80 percent of the peanut acreage had a different crop the previous year and 55 percent had been out of peanuts for 2 years (table A8). The moldboard plow was used on 86 percent of the 1991 peanut acreage, ranging from 96 percent in Georgia to 64 percent in Texas.

Leafspot, early and late, are the two most important peanut diseases. The severity of these diseases is influenced by the weather. High nighttime temperatures and wet leaves from dew or rain are favorable conditions for these diseases. It is important to control early infections. Given appropriate environmental conditions, they will spread if left untreated.

It is important for growers to scout their fields to determine the presence of leafspot because treatment must be initiated immediately. To be effective, the fungicide must be present on the leaf surface before the infection occurs. Otherwise the disease cannot be eradicated once it has become established. Most growers follow a 10-14 day spray schedule once the disease has been identified, modifying it based on weather conditions. Chlorothalonil or chlorothalonil plus sulfur accounted for 92 percent of the fungicide acre-treatments (table A7).

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Sorghum Production Practices and Input Use - 1991

by

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Abstract: This article presents information on the application of agricultural inputs to 1991 sorghum production. Sorghum production practices are similar to corn and are influenced by those of other crops grown in the region.

Keywords: Sorghum production, input use, cropping patterns, tillage system, seed, fertilizer, pesticide.

Grain sorghum is grown predominantly in the Southern Great Plains area, primarily because of its drought-resistant qualities. The leading producing States (Kansas, Nebraska, and Texas) planted 73 percent of total 1991 U.S. sorghum acreage and were included in the survey. Input levels are extremely important to economic profitability in a manner similar to corn.

Cropping Patterns

The most common cropping patterns practiced by farmers in the three surveyed States were continuous sorghum and winter wheat-fallow-sorghum.

In these States, 29 percent of 1991 sorghum acres were following a continuous sorghum cropping pattern. In Nebraska, 38 percent of its 1991 sorghum acres used this pattern. In Texas and Kansas, the share of acreage growing sorghum year after year was 31 percent and 23 percent respectively (table B1).

In Kansas, 34 percent of the 1991 sorghum acres were in a winter wheat-fallow-sorghum cropping sequence. The situation in Texas and Nebraska was 13 percent and 12 percent, respectively. Of the total 1991 sorghum acres, 30 percent were fallow in the preceding year. Sorghum alternated with cotton is popular in Texas while soybeans are alternated with sorghum in Nebraska and Kansas.

Tillage Systems

Conservation tillage systems were used on 25 percent of the 1991 sorghum acres and an average of 40 to 70 percent residue was left of the soil surface (table B2). A substantial share of the acres with conventional tillage resulted in residue cover of about 15 percent. Nebraska reported 51 percent and Kansas 32 percent of the sorghum acreage grown with conservation tillage methods. This is related to the use of conservation tillage systems on the major crops of corn and soybeans. These producers would already have the appropriate machinery for conservation tillage. Texas, on the other hand, had only 4 to 5 percent conservation tillage, reflecting emphasis on the cropping pattern of sorghum following cotton and the conventional tillage normally used in cotton production. Cotton residue is normally eliminated from the field because it provides over-winter habitat for weevils and bollworms.

The time required for tillage operations is closely related to the number of trips over the field. The average number of trips ranged from 3 to 5 and took from .4 to .6 hours per acre

Table B1--Cropping patterns used on land producing sorghum, 1991

Previous crop		Sorghum			
1990	1989	KS	NE	TX	1991 Area
1991 planted acres (1000) 1/		3400	1450	3200	8050
		Percent			
Corn	Corn	2	2	*	2
Corn	Sorghum	nr	nr	4	2
Corn	Fallow /2	1	2	1	1
Corn	Other	*	4	1	1
Sorghum	Corn	1	nr	3	1
Sorghum	Sorghum	23	38	31	29
Sorghum	Soybean	3	7	nr	2
Sorghum	Fallow	8	4	4	6
Sorghum	Other	*	3	3	2
Soybean	Sorghum	7	12	*	5
Soybean	Soybean	4	2	nr	2
Soybean	Fallow	4	1	*	2
Soybean	Other	1	2	*	1
Fallow /2	Sorghum	5	3	7	5
Fallow	Winter wheat	34	12	13	22
Fallow	Other	4	3	3	3
Cotton	Sorghum	nr	nr	18	7
Cotton	Cotton	nr	nr	5	2
Cotton	Other	nr	nr	2	1
Sub-total		97	95	95	96
Other	Other	3	5	5	4
	Total	100	100	100	100

nr = None reported. * = Less than 1 percent.

1/ Preliminary. 2/ No crops planted.

1/ The authors are agricultural economists with the ResourcesTechnology Division, Economic Research Service, USDA.

Table B2--Tillage systems used in sorghum production, 1991

Category	Sorghum KS	NE	TX	Area
Planted acres (1,000) 1/	3,400	1,450	3,200	8,050
	----- Percent of acres 2/ -----			
Tillage system:				
Conv/w mbd plow 3/	1	id	11	5
Conv/wo mbd plow 4/	66	48	84	70
Mulch-till 5/	30	35	4	21
No-till 6/	2	16	id	4
Residue remaining after planting:	Percent of soil surface covered			
Conv/w mbd plow	2	id	*	*
Conv/wo mbd plow	14	17	5	10
Mulch-till	42	37	43	40
No-till	78	74	id	70
Average	24	33	7	18
	----------- Number -----------			
Hours per acre:				
Conv/w mbd plow	1.0	id	.8	.8
Conv/wo mbd plow	.5	.4	.6	.6
Mulch-till	.4	.3	.4	.4
No-till	.1	.1	id	.1
Average	.5	.3	.6	.5
Times over field:				
Conv/w mbd plow	5.8	id	6.2	6.1
Conv/wo mbd plow	4.6	3.3	5.6	4.9
Mulch-till	3.5	2.8	3.4	3.3
No-till	1.0	1.1	id	1.1
Average	4.2	2.8	5.5	4.5

id = Insufficient data. * = less than 1 percent.

1/ Preliminary. 2/ May not add to 100 due to rounding. 3/ Conventional tillage with moldboard plow--any tillage system that includes the use of a moldboard plow and has less than 30 percent residue remaining after planting. 4/ Conventional tillage without moldboard plow--any tillage system that has less than 30 percent remaining residue and does not use a moldboard plow. 5/ Mulch-tillage--system that has 30 percent or greater remaining residue after planting and is not a no-till system. 6/ No-tillage--no residue-incorporating tillage operations performed prior to planting; allows passes of non-tillage implements, such as stalk choppers.

for over 90 percent of the sorghum acreage. The time requirements ranged from .1 hour per acre with about one trip for no tillage systems to more than .8 hour per acre with more than six trips for conventional tillage with the moldboard plow.

Seeds

Seeding rates varied in surveyed States because of a wide variety of soil, fertility, and moisture conditions. In humid or irrigated regions, where moisture is adequate, seeding rates per acre are higher because crops are more intensively farmed. In dryland conditions, seeding rate are lower. In 1991, seeding rates varied from 4 pounds per acre in Kansas to 7 pounds in Texas (table B3).

The average seeding cost per acre was $4.23. Texas had the highest rate and, therefore, the highest cost per acre. Farmers in all the States used purchased seed because of hybridization.

Table B3--Sorghum seeding rates and seed cost per acre, 1991 1/

States	Acres planted	Rate per acre	Cost per acre
	1,000	Pounds	Dollars
Kansas	3,400	4	3.72
Nebraska	1,450	6	3.60
Texas	3,200	7	5.07
1991 average 2/	8,050	6	4.23

1/ States planted 73 percent of U.S. sorghum acres in 1991. 2/ Preliminary.

Fertilizer

Fertilizer was applied on 86 percent of the acres planted in sorghum for the area (table B4). Eighty-six percent of the acres received nitrogen, 44 phosphate, and 11 potash. Nebraska acres received the most nitrogen at 91 percent while Kansas and Texas acres received the most phosphate and potash at about 48 and 13 percent, respectively.

Nutrient application rates for nitrogen, phosphate, and potash averaged 76, 34, and 22 pounds per acre, respectively, for the area. Sorghum in Texas received the most nitrogen at 89 pounds per acre. Kansas and Texas received the most phosphate at 34 pounds per acre. Nebraska received the least amount of potash, 2 pounds.

Ninety percent of all fertilizer was applied at or before planting and 6 percent after planting for the area. Kansas applied the least amount after planting. Only 2 percent of Nebraska acres received fertilizer before, at, and after planting.

Pesticide Use

Surveys of pesticide use in sorghum production were conducted in 1980, 1987, and 1991. The sample design was the same for all years but the number of States surveyed and the information collected varied among surveys. The surveys included 6 States in 1980, 4 in 1987, and 3 in 1991. In all years, data on pesticide material applied, proportion of acres treated, and number of acre-treatments was obtained. Pesticide quantity information was obtained in only 1980 and 1991.

Herbicides

In 1991, herbicides were used on 78 percent of the sorghum acreage (table B5) compared with 82 percent in 1987 and 61 percent in 1980. The average number of treatments per year was 1.2 in 1991 and 1.0 in 1987 and 1980.

Atrazine applied either as a single active ingredient or in combination with other materials was the most commonly used herbicide in sorghum production in all years. It can be applied preplant or preemergence to control germinating weeds. It can also be applied postemergence to control existing weeds with residual activity for late germinating weeds.

Table B4--Fertilizer use on sorghum, 1991

State	Acres planted 1/	Fields in survey	Acres receiving: Any fertilizer	Acres receiving: N	Acres receiving: P205	Acres receiving: K20	Application rates: N	Application rates: P205	Application rates: K20	Proportion fertilized: At or before seeding	Proportion fertilized: After seeding	Proportion fertilized: Both
	1,000	No.	Percent				Pounds per acre			Percent		
Kansas	3,400	489	90	90	47	13	70	34	27	94	3	3
Nebraska	1,450	102	91	91	27	2	68	27	2 *	92	5	2
Texas	3,200	238	79	79	48	13	89	34 *	19 *	84	10	7
Area	8,050	829	86	86	44	11	76	34	22	90	6	4

* = CV greater than 10 percent.

1/ Preliminary.

Table B5--Selected herbicides used in sorghum production, 1991 1/

Item	KS	NE	TX	Area	----KS---	----NE---	----TX---	---Area--
1,000 acres planted	3400	1450	3200	8050				
1,000 acres treated with herbicides	2705	1322	2241	6268				
Percent of planted acres treated:	80	91	70	78				
With 1 treatment	69	70	62	66				
With 2 treatments	10	21	8	11				
With 3 treatments	1	nr	nr	*				
Average times applied	1.17	1.23	1.11	1.16				
1,000 acre-treatments 2/	3164	1621	2498	7282				
Acre-treatments by active ingredient: 3/	--------Percent--------				----Average a.i. rate per acre per treatment------			
Single materials--								
Atrazine	43	19	55	42	1.16	1.03	0.74	0.96
Metolachlor	5	4	9	6	1.53	1.65	1.48	1.52
2,4-D	3	11	6	6	0.33	0.31	0.34	0.33
Other single	9	4	9	8	1.21	1.04	0.72	1.01
Combination mixes--								
Atrazine/Alachlor	7	12	5	7	0.99/1.76	0.99/1.38	0.94/1.56	0.98/1.57
Atrazine/Metolachlor	13	18	15	15	1.16/1.44	1.13/1.52	0.60/0.86	0.96/1.26
Propachlor/Atrazine	4	20	nr	6	2.00/0.75	1.79/0.67	nr/nr	1.85/0.69
Atrazine + others	7	4	3	5	0.70/0.37	0.63/0.34	0.90/0.25	0.73/0.34
Other 2-way combination mixes	4	2	1	2	1.41	0.99	0.73	1.29
3-way combination mixes	3	2	nr	2	2.81	2.28	nr	2.68
4-way combination mixes	1	3	nr	1	3.23	3.47	nr	3.38
All applications	100	100	100	100	1.59	1.80	0.96	1.42

nr = None reported. * = Less than 1 percent.

1/ Preliminary. 2/ Acres treated x times applied. 3/ Spot treatments not included.

Atrazine applied alone accounted for 42 percent of the acre-treatments in 1991, 28 percent in 1987, and 31 percent in 1980. For atrazine combinations, the numbers are 36 percent in 1991, 39 percent in 1987, and 27 percent in 1980.

The average application rate per acre-treatment for atrazine applied as a single active ingredient was 1.0 pound in 1991 compared with 1.4 pounds in 1980. For combination mixes, the atrazine rate was .9 pound per acre-treatment in 1991 and .6 pound in 1980. Thus, over the 12-year period, application rates showed little change.

Metolachlor was the second most commonly used herbicide in 1991, accounting for 6 percent of the single ingredient and 15 percent of the combination acre-treatments. It is applied preplant or preemergence. Combining atrazine and metolachlor in a mixture broadens the spectrum of weed control. Atrazine controls many broadleaf weeds and several grass species. Metolachlor, on the other hand, is more effective on grassy weeds and less effective on broadleaf species than atrazine.

In 1987 and 1980, propazine and 2,4-D were the second most commonly used herbicides, accounting for about 15 and 12 percent of the acre-treatments, respectively. The manufacturer has discontinued the sale of propazine since a seed safener was developed to protect the sorghum seed from atrazine injury. Thus, atrazine has replaced propazine in the market place. Applied postemergence, 2,4-D controls existing broadleaf weeds.

The three- and four-way combination mixes accounted for 3 percent of the acre-treatments in 1991 and were used in no-till production systems. All of the mixtures contained

atrazine, 85 percent 2,4-D, and about 70 percent glyphosate or paraquat. Glyphosate and paraquat are nonselective herbicides that control existing weeds but have no residual activity. Atrazine controls existing weeds and has residual activity for germinating weeds while 2,4-D controls only existing broadleaf weeds. By mixing these materials and applying them in a single application, a fairly complete burndown of existing vegetation is obtained, clearing the soil surface for the planting operation. Metolachlor and alachlor were frequently added to the mixtures to broaden the spectrum of control and provide residual activity.

In addition to herbicides, farmers use mechanical cultivation to control weeds during the growing season. In 1991, 69 percent of the sorghum acreage was cultivated an average of 1.7 times (table B6). Texas growers cultivated the most often, 2 times, while Kansas growers averaged the least, 1.3 times.

Table B6--Weed control cultivations used in sorghum production, 1991 1/

Item	KS	NE	TX	Area
1,000 acres planted	3400	1450	3200	8050
1,000 acres cultivated	1801	981	2844	5627
Percent of planted acres cultivated:	53	68	89	69
With 1 cultivation	41	41	24	34
With 2 cultivations	9	24	47	26
With 3 cultivations	2	3	13	6
With 4 or more cultivations	*	nr	5	3
Average times cultivated	1.28	1.43	2.05	1.70

nr = None reported. * = Less than 1 percent.

1/ Preliminary.

Insecticides

In 1991, insecticides were used on 16 percent of the sorghum acreage compared with 17 percent in 1987, and 24 percent in 1980 (table B7). Insect infestations vary from year to year depending on environmental conditions. Farmers applied 1.2 insecticide treatments per acre in 1991 compared with slightly over 1.0 treatment in 1980. Data on acre-treatments and materials used were not published for 1987.

Carbofuran was the most commonly used insecticide in sorghum production in 1991, accounting for 23 percent of the acre-treatments. In Kansas, it accounted for 79 percent of the acre-treatments. Chlorpyrifos was second in importance and was used throughout the three States. Ethyl parathion use was highest in Nebraska while terbufos was used in Nebraska and Texas. In 1980, carbaryl, carbofuran, and ethyl parathion were the most commonly used insecticides.

Carbofuran is applied in the seed furrow at planting. It controls soil-dwelling insects such as seed corn maggot, corn rootworm larvae, and wireworms. In addition, it is a systemic insecticide which is taken up by the plant and controls foliage- feeding insects such as chinch bugs, flea beetles, and greenbugs.

Chlorpyrifos is used primarily to control sorghum midge. The midge lays its eggs in the seed head during bloom and when the eggs hatch the larvae feed on the developing seed reducing yield. Texas growers use several other materials for sorghum midge control, including dimethoate, malathion, and methomyl. Dimethoate is also used for spider mite and Banks grass mite control.

Fungicides

Survey respondents reported no fungicides in sorghum production.

Table B7--Selected insecticides used in sorghum production, 1991 1/

Item	KS	NE	TX	Area	KS	NE	TX	Area
1,000 acres planted	3400	1450	3200	8050				
1,000 acres treated with insecticides	292	85	932	1309				
Percent of planted acres treated:	9	6	29	16				
With 1 treatment	9	6	25	15				
With 2 treatments	nr	nr	4	1				
Average times applied	1.00	1.00	1.28	1.20				
1,000 acre-treatments 2/	292	85	1188	1566				
Acre-treatments by active ingredient: 3/	Percent				Average a.i. rate per acre per treatment			
Single materials--								
Carbofuran	79	33	9	23	1.02	0.98	0.62	0.90
Chlorpyrifos	10	17	17	16	0.83	0.50	0.49	0.53
Ethyl parathion	10	33	7	9	0.80	0.25	0.72	0.64
Terbufos	2	17	14	12	1.05	1.24	0.73	0.78
Other	nr	nr	53	41	nr	nr	0.47	0.47
All applications	100	100	100	100	0.98	0.70	0.54	0.63

nr = None reported. * = Less than 1 percent.

1/ Preliminary. 2/ Acres treated x times applied. 3/ Spot treatments not included.

The Situation and Outlook for Manufactured Agricultural Inputs in Poland [1/]

by

Aldon Zalewski, Jan Pawlak, Grzegorz Skrzypczak, and Stan Daberkow [2/]

Abstract: The transition from a centrally planned to a market economy in Poland has been accompanied by dramatic changes in the production, consumption, prices and trade of manufactured agricultural inputs such as fertilizers, pesticides, and farm machinery. Withdrawal of state production subsidies, along with economy-wide inflationary pressures, resulted in dramatic price increases for manufactured inputs while agricultural commodity prices by farmers rose only modestly. Consequently, between 1988 and 1991, NPK fertilizer use per hectare fell 51 percent (176 kg. to 95 kg.); pesticide use (a.i.) per hectare declined 73 percent (1.6 kg. to 0.4 kg.); tractor sales were down 82 percent (69,400 to 12,600; and energy use on farms was off 20 percent. With the exception of fertilizer, which may fall another 30-40 kg per hectare, manufactured input use and sales are expected to stabilize in 1992.

Keywords: Poland, fertilizers, pesticides, farm machinery, agricultural inputs.

Polish agriculture is undergoing significant changes as the entire economy moves toward a market system. The manufactured agricultural input industries in Poland, including fertilizers, pesticides, and farm machinery, are faced with a number of adjustments which are linked to the economic behavior of farmers during this transition period. In turn, farmer behavior with respect to agricultural inputs is largely driven by the domestic and international demand for agricultural commodities.

Commodity Markets and Macroeconomic Situation

Since 1989, record yields, reduced domestic and export demand for agricultural commodities, and some increased food product imports resulted in stagnating or only modestly increasing agricultural commodity prices during a time of economy-wide inflationary pressures. Excellent weather during the last 3 years boosted yields and production of most major crops, except sugarbeets and potatoes where yields fell in 1991. Increased unemployment and declining per capita real income has dampened domestic food demand especially for livestock products (table C1). Agricultural export markets have been adversely affected by the collapse of markets in the Commonwealth of Independent States (CIS) countries as well as an unwillingness of West European countries to further open their markets to Polish food products. In addition, some increase in selected food imports has contributed to weakness of domestic commodity prices relative to the general inflation rate. As a result of these relative price movements, farm income has dropped significantly since 1989.

Inflationary pressures were particularly rampant during 1989 and 1990 when price controls were removed and state subsidies to industries were reduced. These rapid price increases were followed by rising interest rates. However, in 1991, the rate of increase in consumer prices and interest rate levels fell significantly. By most market economy standards, both of these indicators remain at unsustainable levels.

Fertilizer Use Indicators

Rapid price increases for fertilizer products and stagnating crop prices have resulted in a major drop in aggregate and per hectare use of fertilizer since 1988. Between 1988 and 1991, fertilizer prices increased 50 to 100 times, depending on the specific product. For example, triple superphosphate (granules) prices rose from 3,049 to 182,653 zlotys/100 kg. During the same period, crop prices rose much more mod-

Table C1--Macroeconomic indicators of the Polish economy

Year	Unemployment Rate	Change in Consumer Prices	Change in Real Wages	Interest Rate Charged by Banks
		Percent		
1988	n/a	61.3	14.4	16.7
1989	n/a	243.8	9.0	64.0
1990	6.3	685.8	-24.4	101.4
1991	11.8	70.3	1.0	55.0

n/a = Not available

Source: (1, 2)

1/ The Economic Research Service, under the auspices of the SEED II Act administered by AID, has an agreement with the Polish Ministry of Agriculture to initiate Situation and Outlook reports on the Polish agricultural sector, including oilseeds, grains, sugarbeets, fruits and vegetables, dairy, poultry, livestock, fertilizers, pesticides, and farm machinery.

2/ The authors are from the Institute of Agriculture and Food Economics, Warsaw; the Institute for Buildings, Mechanization, and Electrification, Warsaw; Academy of Agriculture, Poznan; and the Economic Research Service, USDA, Washington, D.C., respectively.

estly. The superphosphate/wheat price ratio grew from 1.0 to 5.0 from 1988 to 1991, while the same ratio for rye increased from 1.4 to 8.3 and for potatoes rose from 2.8 to 12.1. Consequently, the per hectare use of elemental nitrogen(N), phosphate(P) and potassium(K) fell from 176.4 kg. per hectare to 95.1. Aggregate use of N,P, and K declined from 3.94 million metric tons to less than 2 million metric tons. Forecasts for 1992 are for NPK use per hectare to fall into the range of 40-50 kg.

Since much of the soil in Poland is acidic, calcium fertilizer is very important, although use per hectare has declined. In 1989, calcium consumption was 202 kg. per hectare but by 1991, use had fallen to 139 kg.

In addition to declining domestic demand, fertilizer producers are facing reduced subsidies from state sources, increased production costs as energy prices rise to world market levels, and potential competition from imports. In some cases, producers have attempted to maintain revenues and generate income by raising prices rather than cutting costs. Some fertilizer producers have successfully increased exports as domestic demand fell. At the same time, the government has imposed a 15 percent tariff on imports thus sheltering vulnerable plants from foreign competition. To the extent that imports are less expensive than domestic sources, fertilizer tariffs are an additional burden on Polish farmers. Fertilizer producers in the CIS countries are particularly well situated to enter the Polish market.

Implications from the current situation affect both fertilizer consumers and producers. Through 1991, the severe reductions in fertilizer usage have not affected yields with the possible exception of potatoes and sugar beets. However, over time soil productivity may be adversely impacted if nonsynthetic fertilizers, such as legumes and manures, are not substituted for synthetic sources. Large reductions in fertilizer demand has exposed producers to added costs due to excess capacity. In some cases, plant efficiency is not sufficient to be competitive and therefore joint ventures with Western companies will be necessary for survival. Efforts to reduce costs are also complicated by the government goal of privatizing most manufacturing plants. Other concerns have been raised about the adequacy of the fertilizer storage facilities and distribution system from plants to local suppliers.

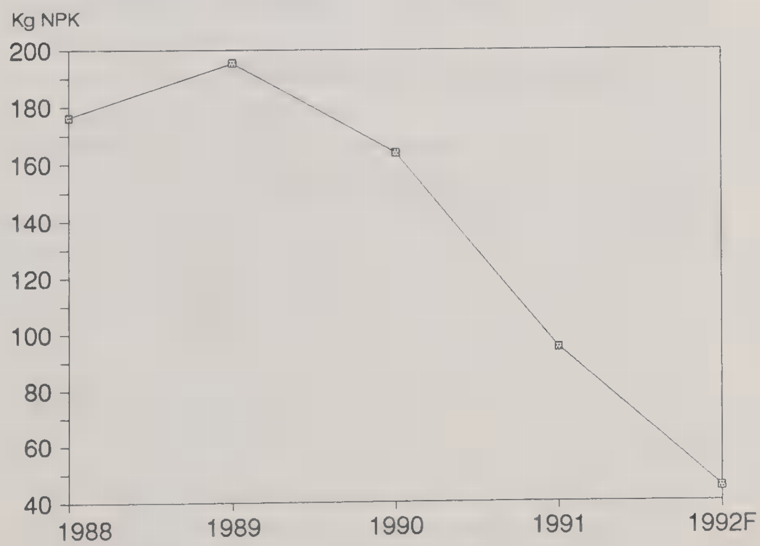
Pesticide Use Indicators

Pesticide use in Poland appears to be following the pattern established by fertilizer: declining use as prices increased much faster than crop prices. For example, Afalon (linuron), a herbicide used on field crops and vegetables, experienced a price increase from 3,675 to 126,000 zlotys per kg. from 1989 to 1991. During the same period, the Afalon/wheat price ratio grew from 0.3 to 1.3; for rye, the ratio increased from 0.4 to 2.2; and for potatoes, the ratio changed from 0.4 to 3.2. Consequently, active ingredient (a.i.) use per hectare in Poland went from 1.62 kg. in 1988 to 0.37 kg. in 1991. Aggregate a.i. use declined 72 percent from an estimated 23.8 million metric tons to 6.3 million. Forecasts for 1992, indicate that usage will likely stabilize or even increase slightly depending on weather and pest infestations.

Polish pesticide producers are primarily formulators (i.e., plants which import basic materials and formulate and package products for farm use) and face circumstances similar to those of fertilizer plants. Domestic pesticide production is estimated to have fallen over 40 percent between 1988 and

Figure C1

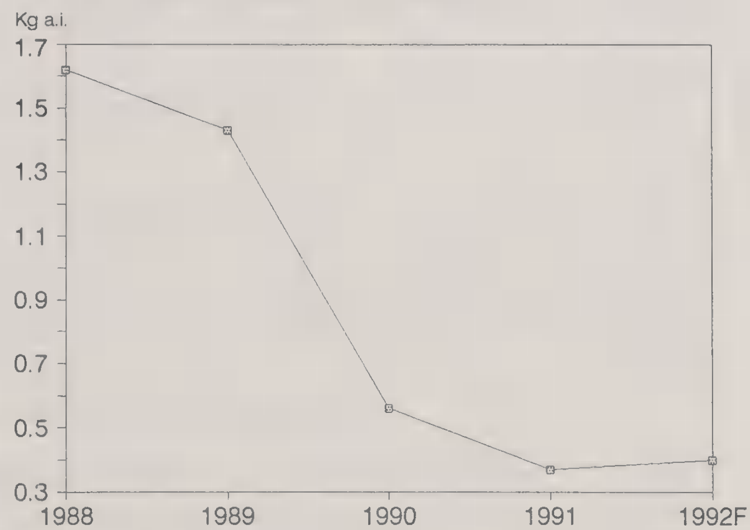
NPK Fertilizer Use Per Hectare of Cropland, 1988-92



F=forecast

Figure C2

Pesticide Use (a.i.) Per Hectare of Cropland, 1988-92 1/



1/ a.i. = active ingredient
F=forecast

1991, while imports likely declined over 80 percent. These establishments are also facing the prospect of privatization at a time demand for their product is falling.

While pesticide formulators are attempting to adjust to a market economy driven by farmer demands and cost considerations, the fall in use may also have implications for crop yields and production. Pest infestation will likely be a key factor in determining yield effects as will the availability of nonchemical alternatives such as resistant varieties, farm labor resources, and crop rotations.

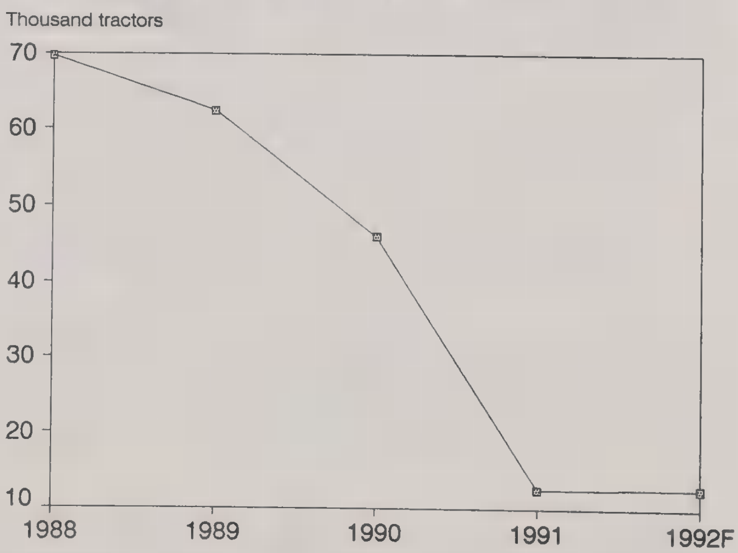
Farm Machinery Indicators

Investment by farmers in farm machinery and tractors has been reduced by the declines in farm income, rapidly increasing machinery prices relative to commodity prices, very high nominal and real interest rates, the uncertainty of future prices, and government market intervention policies. While direct measures of farm income are not available, farm income in 1991 was only about 63 percent of the level of the mid-1980's. The price of an Ursus tractor (C-330) increased by a factor of 32, indicative of the price changes occurring for all farm machines between 1988 and 1991. Relative to livestock and crop prices, machinery prices often increased 3-5 times faster.

The radical departure from a guaranteed government procurement price for most commodities has introduced an element of price risk into the decision to make investments in farm machinery. As a result of these factors, sales of farm machines fell significantly between 1988 and 1991, with sales of tractors falling from 69,700 to 12,600. With some expected improvement in farm prices in the latter part 1992, tractor sales for the year may stabilize in the 12-13,000 unit range.

Figure C3

Sales of Farm Tractors, 1988-92



F=forecast

With the steep fall in machinery sales, manufacturing plant output has dropped nearly 60 percent since 1988. For most farm machinery plants, production plans were dictated by central planning agencies until 1989. After 1989, plant managers were faced with not only production decisions, at a time when raw material prices were rapidly escalating and state subsidies were reduced, but they also had to assume a marketing function. Anticipating farmer demand and evaluating the factors influencing demand, is an unfamiliar task. Consequently, inventories of some machines have grown extensively while demand has been falling. Several plants are on the verge of bankruptcy, while others, such as Ursus and Agromet, are undergoing ownership changes. The imposition of a 35 percent tariff has sheltered several producers from international competition.

The small size of most farms in Poland (i.e., the average private farm is 6-8 hectares) and the abundance of labor in many agricultural areas have also slowed the investment in farm machinery. Until nonfarm job opportunities increase, labor resources may actually be attracted into the agricultural sector. Nominal and real (i.e., inflation adjusted) interest rates for farmers are high by historical standards, which is also discouraging investment.

Farm machinery producers are expected to lower costs rather than maintain revenues through price increases. Greater emphasis on marketing is also expected. Attention will be focused on establishing dealer networks, improving parts distribution, discounting, and creating a farmer credit program. Privatization efforts and joint ventures will likely continue as the industry adapts to market conditions.

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Restricting Pesticide Use: The Impact on Profitability by Farm Size

by

Gerald Whittaker, Biing-Hwan Lin, and Utpal Vasavada[1/]

Abstract: A sample of 226 cash grain farms in the Lake States-Corn Belt region are analyzed to estimate the impact of restricting pesticide use on profits. These 226 farms are classified into small, medium, and large according to their sale revenues. The results suggest that limiting per-acre pesticide expenditures to no more than $22 has a negligible impact on profits. When pesticide expenditures are further tightened, the reductions in profits increase with farm size.

Keywords: Farm pesticide use, profit, farm size.

Pesticide use in agriculture has been viewed as a double-edged sword. Higher pesticide use has contributed to the modernization of agriculture, which is characterized by major changes in production techniques, shifts in input use, and growth in productivity. At the same time, there has been increasing pressure to regulate pesticide use, reflecting rising concerns about residues in food and water, as well as other potential health and environmental risks.

Between 1964 and 1989, pesticide use in agricultural production increased from 320 million pounds of active ingredients (a.i.) to 806 million pounds (1). Corn and soybeans lead other crops by a substantial margin in terms of total pesticide use. In 1991, 94 percent of the 68 million acres of corn were treated with herbicides and 30 percent were treated with insecticides, compared to only 11 percent and 1 percent, respectively, in 1952 (14,19). The 1991 corn acres consumed 226 million pounds of herbicide a.i. and 27.9 million pounds of insecticide a.i. (18). Of the 53 million acres of soybeans planted in 1991, 96 percent were treated with herbicides, compared to 68 percent in 1971. The 1991 soybean acres received 106 million pounds of herbicide a.i. while only 2 percent were treated with insecticides.

As a response to such a high level of agricultural pesticide and chemical fertilizer use, interest in alternative approaches to food and fiber production has increased. Changes in production practices have been advocated under such titles as sustainable agriculture, alternative agriculture, and low-input sustainable agriculture. These production systems seek to rely more on nonchemical control of pests so that pesticide use in agriculture can be reduced, but in most cases not totally eliminated. At the same time, public debates on reducing agricultural chemical use through regulation or policy changes have intensified.

Reduced pesticide use, whether or not by regulation, will affect farm financial performance, the mix of outputs produced, and the allocation of resources. The reduction in profits when farmers switch to less chemical-intensive production can be viewed as the incentive that farmers might need to adopt environmentally harmonious production technologies.

How less pesticides affect profits, by farm size, is important to policy makers. What effect will these changes have on family farms and rural life? This study evaluates the financial consequences of reduced pesticide use on small, medium, and large cash grain farms in the Corn Belt-Lakes States production region.

Approach

Numerous studies have been conducted to determine the costs and benefits associated with pesticide use (7,9,12). Methods that have been applied to assess the costs of banning or reducing pesticide use include partial budgeting (4), economic surplus models (6), farm-level linear programming (3), spatial equilibrium linear programming (2,16), econometric simulation (8,11,13,17), and a computable general equilibrium model (15). None of these methods has been applied to assess the impacts, by farm size, of reducing pesticide use. In fact, this issue has received little attention in the literature.

This study analyzes the financial impacts of reducing pesticide use, not policy options nor ways to achieve a particular level. Alternative approaches for reducing pesticide use include banning a particular pesticide a.i., a group of pesticides a.i., use in terms of quantity, use in terms of expenditure, and taxing the use. We chose reductions in per acre pesticide expenditure due to the available data.

To assess the profit impacts of constraining pesticide expenditures, we utilize a linear programming (LP) model with and without a pesticide expenditure constraint. Without the constraint, the LP solution establishes the maximum attain-

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able profit. The LP model with the pesticide constraint generates the constrained maximum attainable profit. The difference between the two attainable profits provides a measure of the profit loss attributable to the pesticide expenditure constraint. The approach has recently been applied to address agriculture-related issues (5,10,20).

Data

The data consist of 226 cash grain farms, a subset of 826 soybean producing farms enumerated in the 1990 soybean version of the Farm Costs and Returns Survey (FCRS). The subset of FCRS data analyzed here represented 84,053 cash grain farms in the Lake States-Corn Belt production region including Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin. Over 90 percent of these farmers' income, on average, came from corn, soybean, and wheat production. All the farms included in the analysis had less than $100 in livestock sales, and none had irrigation expenses.

The 226 farms were classified into small, medium, and large. Small farms are defined as those with sales of less than $40,000, a threshold that commonly distinguishes commercial from noncommercial farms. Medium-size farms had sales of at least $40,000 but below $150,000. Farms with sales of $150,000 or more are classified as large. The numbers of small, medium, and large farms are 72, 78, and 76, respectively.

Table D1: Sample characteristics (median values) of farms in the 1990 FCRS Soybean Survey

Variable	Small	Medium	Large
Soybean acreage (acres/farm)	39.5	207.5	416.5**
Corn acreage (acres/farm)	32.5	187.5	648.5
Labor expenses ($/acre)	125.84	86.52	54.44
Fertilizer expenses ($/acre)	30.40	36.98	33.09
Seed expenses ($/acre)	19.48	20.10	20.77
Total pesticide expenses ($/acre)	21.39	29.88	25.60
Pesticide expenses on:			
soybeans ($/acre)	19.28	20.12	20.51
other crops ($/acre)	20.19	43.16	28.00
Fuel expenses ($/acre)	15.62	12.88	14.37
Machinery repairs ($/acre)	23.11	17.38	14.74
Building repairs ($/acre)	9.78	3.88	1.17*
Tool costs ($/acre)	8.31	3.00	3.33
Custom work cost ($/acre)	11.78	3.94	4.20**
Business expenses ($/acre)	121.06	137.28	126.45
Number of farms	72	78	76

* Null hypothesis of equality rejected at 10 percent significance level.

** Null hypothesis of equality rejected at 5 percent significance level.

Table D1 summarizes the uses of fixed and variable inputs of the sample farms. Because the distributions of these characteristics are markedly asymmetrical, we report the median values rather than the mean values.

Land is treated as a fixed input as is its allocation among soybean, corn, and wheat production. The median soybean and corn acres are 39.5 and 32.5 for small farms, 207.5 and 187.5 for medium, and 416.5 and 648.5 for large. Some farms planted wheat, but the majority of the sample did not and the median wheat acres are zero for all farm sizes. The median soybean and corn outputs are 1,426 and 3,527 bushels for small farms, 8,025 and 22,738 bushels for medium, and 16,050 and 61,320 bushels for large.

In estimating the maximum attainable profit for each farm, variable input use is allowed to change for all three crops. Pesticide expenditures are itemized into five categories: insecticides; herbicides; fungicides; desiccants, defoliants, and growth regulators; and other pesticides. The median per acre pesticide expenses for soybean production ranged from $19.28 for small farms, to $20.12 for medium, and $20.51 for large. The differences were not statistically significant. Corn accounted for the bulk of the production of other crops on soybean farms. Consequently, the per-acre pesticide expenditures for other crops were greater than those for soybeans, especially among medium and large farms. In terms of pesticide expenditures for all crops, the median per acre figures were $21.39 for small farms, $29.88 for medium, and $25.60 for large.

Results

Constraints on per acre pesticide expenditures analyzed are $6, $10, $14, $18, $22, $26, and $30. When no pesticide expenditure constraint is imposed on the model, median maximum attainable profit per acre for small farms was $83. The median profit per acre for medium farms was $147. For large farms, the median profit per acre was $125.

Table D2. Profits and pesticide expenditures.

Farm Size	Per-acre limits on pesticide expenditures ($)						
	30	26	22	18	14	10	6
	Per-acre profit (decline) ($)						
Small	83.08 (0)	83.08 (0)	82.93 (0.15)	82.21 (0.72)	81.26 (0.95)	79.98 (1.28)	65.68 (14.30)
Medium	147.06 (0)	146.97 (0.09)	146.01 (0.96)	146.01 (0)	140.53 (5.48)	124.84 (15.69)	108.12 (16.72)
Large	125.91 (0)	125.91 (0)	125.31 (0.60)	117.32 (7.99)	107.21 (10.11)	96.64 (10.57)	79.21 (17.43)

Note: The numbers in parentheses are the declines in profits when pesticide expenditures are restricted from the next higher levels.

The impacts of pesticide expenditure constraints on profit are summarized in table D2. None of the efficient farms spent more than $30 per acre on pesticides. Therefore, a $30 per acre constraint on pesticide expenditure did not reduce profit. When the constraint was tightened to $26, only medium farms were affected. However, the maximum attainable profit was reduced by only $0.09 per acre. Restricting pesticide expenditure to $22 from $26 also had negligible impacts on all farm sizes, resulting in $0.15, $0.96, and $0.60 reductions in per-acre profit for small, medium, and large farms, respectively.

Losses in profit began to amplify, especially among large farms, when pesticide expenditures were restricted below $22 per acre. A $4 reduction from $22 in per-acre pesticide expenditures caused a large farm's profit to decline by almost $8 per acre, implying a marginal revenue of $2 for each dollar of pesticide expenditure over the relevant range of $18 to $22 per acre.

However, the same reduction in pesticide expenditures did not affect the profitability of medium farms. In the case of small farms, the same $4 reduction resulted in a loss of $0.72 per acre. This suggests that small and medium farms are less adversely impacted than large farms over the $18-to-$22 per-acre pesticide expenditures.

When expenditures were below $18 per acre, both medium and large farms experienced substantial losses in profits, suggesting small farms are the least impacted by the pesticide use constraint. In fact, small farms did not feel much financial impact until the pesticide expenditure was less than $10 per acre.

A reduction from unconstrained to $10 per acre resulted in a profit decline of $3 per acre for small farms, compared to $22.22 for medium, and $29.27 for large. Medium farms started to experience substantial financial impacts when pesticide expenditures were $14 per acre. Large farms were most impacted by the pesticide use constraint, with drastic financial squeezes when pesticide expenditures were $18 per acre.

Summary

Many interest groups, including the agricultural community, have a strong interest in switching to alternative production practices and systems using fewer agricultural chemicals in order to improve food safety and to arrest environmental degradation. When a shift to low-input production practice reduces profit, there is no incentive to adopt the practice. Insufficient technical and economic information on alternative practices also reduces adoption. Information about the profits associated with adopting alternative practices is helpful to public decision-makers seeking to encourage adoption by offering appropriate financial incentives.

The study results suggest that limiting pesticide expenditures to no more than $22 per acre has almost no impact on profits. Reducing pesticide expenditure below $22 per acre is predicted to drastically impact the profit of farms with sales of $150,000 or more but not farms with smaller sales. When pesticide expenditures are limited to no more than $14 per acre, farms with sales of $40,000 or more encounter substantial decline in profit.

Our results also suggest that farms with sales of less than $40,000 show reduced profits when pesticide expenditures are below $10 per acre. Even though farms of different sizes tend to spend similar amounts on pesticides on a per acre basis, the results of our study indicate that the adverse impacts of restricting pesticide expenditures increase with farm size. To understand the factors that contribute to this finding, we need information such as pest control and other management practices as well as social characteristics of the farm. Future research will focus on the use of other survey data to examine the impacts of restricting pesticide use on profitability by farm size as well as the reasons causing differing impacts across farm sizes.

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Testing for Impacts of Immigration Reform on Farm Employment and Wages

Harry Vroomen and James Duffield [1/]

Abstract: This article examines the effects of the Immigration Reform and Control Act (IRCA) of 1986 on the U.S. agricultural labor market. Results provide no evidence that IRCA had a significant impact on U.S. farm employment or wages. There was no indication that employer sanctions issued under IRCA reduced the farm labor supply. At the same time, empirical findings do not suggest that the farm labor supply increased significantly after the passage of IRCA.

Keywords: Immigration Reform and Control Act, agricultural labor, and intervention analysis.

The Immigration Reform and Control Act (IRCA) of 1986 established penalties for employers who knowingly hire undocumented workers, instituted an amnesty program for certain illegal aliens, and provided special programs for agricultural workers. Any employer who knowingly hires a person not authorized to work in the United States can be imprisoned for six months and fined up to $10,000 for each instance.

IRCA instituted an amnesty program to minimize economic and social disruptions, and avoid huge enforcement costs of deporting illegal aliens. This program permitted those who had resided in the United States continuously since before January 1, 1982, to apply for legal U.S. resident status. About 1.7 million persons were approved and are eligible to become U.S. citizens.

Many farmworkers were not expected to qualify for the amnesty program because of the seasonal nature of their work. They typically work only a few weeks during the harvest. Thus, many undocumented farmworkers would not be in this country year-round to meet the residency requirement under the general amnesty program. Some growers argued there could be labor shortages and serious disruptions in farm production of labor-intensive crops.

Recognizing that agriculture's needs might not be met by the amnesty program, Congress added the Special Agricultural Worker (SAW) Program for producers of perishable commodities, who have traditionally relied on undocumented workers. It gives farmers additional time to make labor adjustments and helps maintain an adequate U.S. seasonal workforce until the program ends in 1993.

Under the SAW program, enforcement of employer sanctions in agriculture was phased in more slowly than in other sectors of the economy. Enforcement was deferred in most crop agriculture until December 1, 1988, rather than June 1988, as for all other employers. Second, the program legalized about 1 million workers who performed seasonal agricultural services in the United States. Third, in case seasonal labor shortages occur, the program allows for "replenishment agricultural workers" to come into the United States.

If some workers quit working in SAW Program crops, the law requires that a portion of those be replaced by new immigrants each fiscal year from 1990 through 1993. "Replenishment" agricultural workers (RAW's) must work in SAW Program crops for at least 90 days in each of the first 3 years of their U.S. residence to keep from being deported, and must work an additional 2 years in these crops to qualify for U.S. citizenship. As of October 1992, no work visas had been issued under the RAW Program.

Possible Effects of IRCA

The IRCA penalizes employers who continue to hire unauthorized workers. Farm employers are expected to rely on the legal workforce, including a large number of SAW's. However, since SAW's are not required to stay in agriculture, employers fear that many will find higher-paying jobs in the nonfarm sector. Thus, the seasonal labor supply could shrink over time, forcing employers to offer higher wages and benefits to keep workers. Higher wages could increase production costs and lower net revenue for growers of labor-intensive crops.

In the above scenario, wages are driven up because undocumented workers are excluded from the workforce. This viewpoint was widely accepted among farm labor experts and policymakers when IRCA became law in 1986. However, a second scenario emerged. Many farm labor experts argued that immigrant laborers were still coming into the country illegally and working in agriculture. Employer sanctions have been difficult to enforce because undocumented workers can obtain jobs with fraudulent documents which are hard to detect and readily available.

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More undocumented workers than usual may be crossing the border and remaining in the United States in the hope of another amnesty program or an extension of the SAW program. Also, many of the 700,000 illegal aliens who have applied for RAW visas could be living in the United States. Adding these potential workers to the 1 million legalized under the SAW program could substantially increase the farm labor supply. Consequently, there may be a labor surplus in the United States which would drive wages down.

Method of Measuring Program Impacts

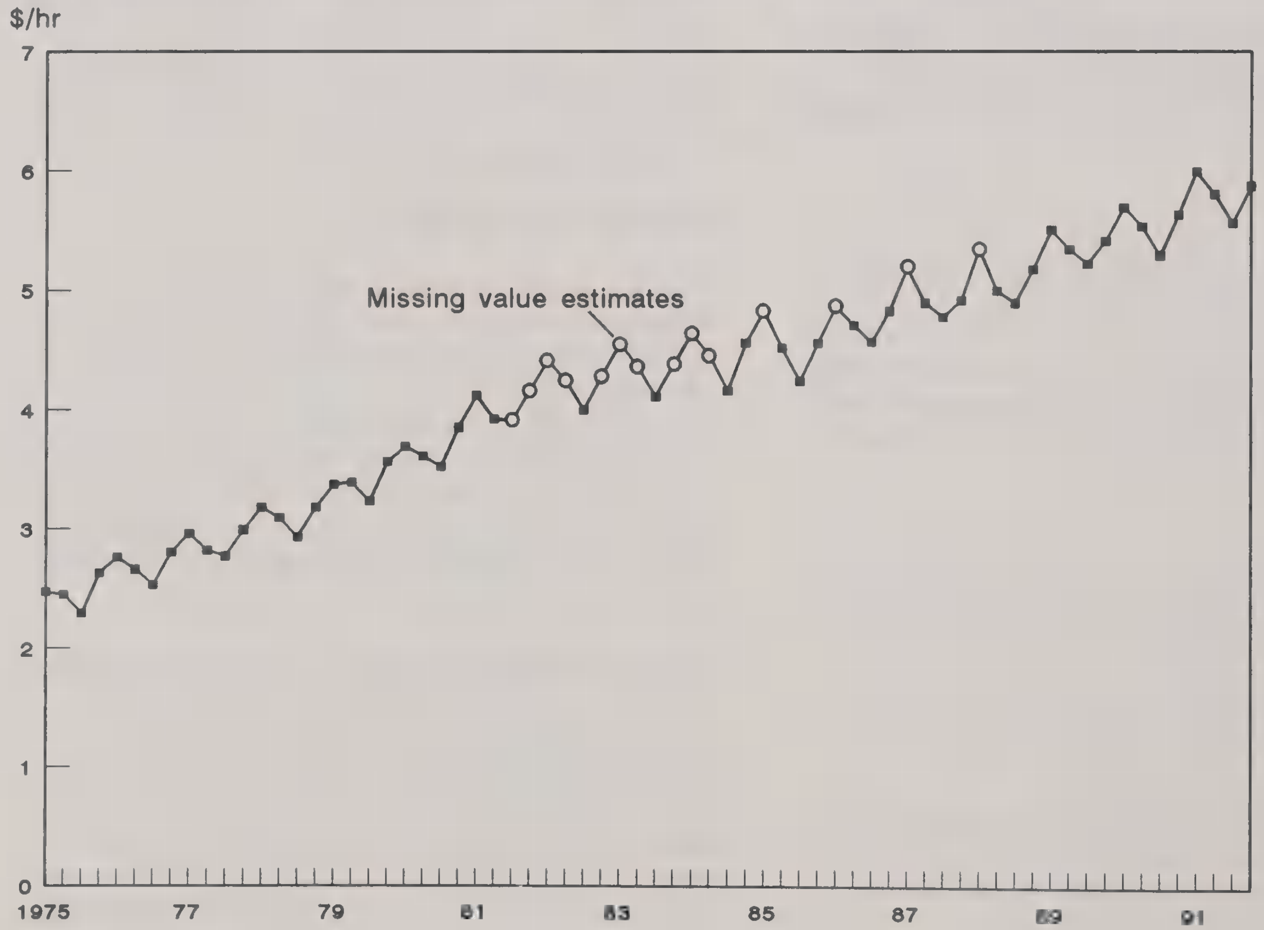
Ideally, we would like to identify changes in the farm labor market exclusively related to IRCA. Unfortunately, this would require information on many economic and social variables that are difficult to obtain or unavailable. We can examine wage and employment data over time, however, to see if the observed values deviate from normal trends after the passage of IRCA.

A plot of actual observations on farm employment and wages over time might indicate IRCA's potential impact. However, other factors can cause movements in these data series that may mask IRCA effects. For example, a plot of U.S. farm wages in figure E1 shows an obvious trend, i.e., farm wages have been rising between 1975-91. Changes in GNP, agricultural productivity, inflation, and minimum wage requirements are just some of the factors that have contributed to this trend. In addition, a recurring pattern within each year is also apparent from figure E1. This pattern is associated primarily with seasonal changes in agricultural production.

The presence of trend and seasonality in the data might obscure any impact resulting from a policy such as IRCA. Therefore, these movements must be removed or filtered from the observed data. Once trend and seasonality have been accounted for, the next step is to identify and remove any autoregressive and moving average components in the data. These components are predictable patterns in the time series related to the dependence of one time period on another. This can be accomplished by using a time-series technique known as ARIMA analysis (3).

Figure E1

U.S. Farm Wages in January, April, July, and October: Wages Are Lowest in July and Peak in January



Missing value estimates are used for quarters NASS did not survey.

ARIMA (autoregressive-integrated-moving-average) models are fit to a collection of successive observations ordered through time known as a time series. A time series plot shows the actual observed data points which are generated by an underlying time series process. The ARIMA approach consists of extracting the predictable movements from the observed data to obtain a concise description of this process by constructing a model to explain the time series behavior. The procedure involves removing the mathematically definable patterns, leaving a time series that is random, and thus unpredictable. These models often can generate an estimated data series very similar to the actual data.

Intervention Analysis

This study employs an extension of the ARIMA time series procedure known as intervention analysis to investigate whether IRCA had a significant impact on farm employment and wages. Intervention analysis tests whether or not "a postulated event caused a change in a social process measured as a time series"(11, p.142). The technique has been used for a variety of social science applications as a means of assessing the impact of Government policies (1,2,5,6,10).

The first step in intervention analysis is to develop an ARIMA model that adequately describes the time series behavior. The second step is to add intervention components to the ARIMA model in order to construct the full intervention model. Intervention components are chosen to fit the observed or theoretical response of the impact being analyzed. The theory of intervention developed in this analysis is based on the impact patterns discussed by Box and Tiao. These patterns can be described by two characteristics, onset and duration. The onset of an intervention can be either abrupt or gradual, and the duration can be either permanent or temporary.

Individuals in the agricultural labor market do not respond instantly to changes in government policy. If IRCA did result in a change in the supply of agricultural labor, the effects on farm employment and wages would not be fully realized for several years (8). Thus, we hypothesized that, if IRCA had an impact on farm employment and wages, the impact was gradual and permanent. Although crop producers were not subject to employer sanctions until December 1988, we expected them to start making labor adjustments shortly after the passage of IRCA. Since IRCA was enacted in November 1986, the intervention component was introduced into the model at the first observation following enactment, the first quarter of 1987.

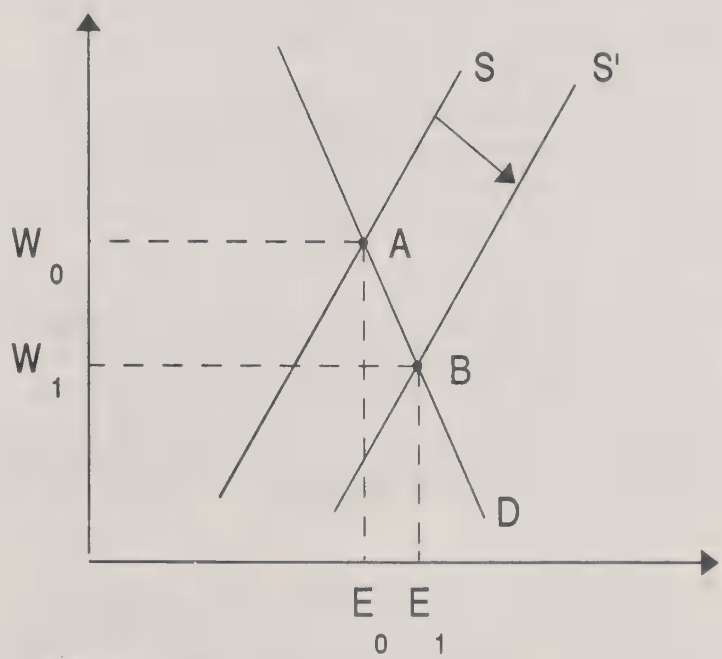
While we are interested in measuring the potential effects of IRCA on agricultural labor supply, data are available only on the actual number of farmworkers employed. Employment data provide an indirect measurement of IRCA's impacts and in some cases may be insensitive to changes in labor supply.

For example, consider the case where the agricultural labor market is initially in equilibrium at point A in figure E2. If the supply of farmworkers were to increase significantly a new equilibrium would be reached at point B. Without a simultaneous increase in agricultural production to create new jobs, we might observe only a small increase in farm employment from E_0 to E_1. Consequently, since available data includes only employed workers, the significant increase in labor supply would not be captured in the farm employment data. However, if farm labor supply were to increase significantly, we should observe a fall in the wage rate from W_0 to W_1.

Similarly, a decrease in the labor supply could occur without a significant decrease in the employment data. The employer sanctions imposed by IRCA were delayed and the SAW program was developed to give crop producers the opportunity to adjust to a legal workforce. Employers had an incentive to attract and retain legal workers because there would be too much risk in routinely hiring unauthorized workers. Employers could attract and retain legal workers by offering them higher wages and more hours of work. Although worker turnover would decrease markedly, the number of workers employed could remain about the same. Thus, even with a large decrease in the labor supply, we would expect to see an increase in the farm wage data, but little change in the number of farmworkers employed.

Figure E2

Effects of an Increase in Labor Supply



W = Farm wage
E = Employment
S = Labor supply curve
D = Labor demand curve
A and B = Equilibrium points

In summary, if IRCA was followed by a surplus of farm labor as some analysts have surmised, the data should show an increase in employment, a decline in wages, or both. Similarly, if IRCA reduced the farm labor supply by controlling illegal immigration, we would expect to find a decrease in the employment data, an increase in wages, or both. Applying the characteristics of onset and duration to the expected effects of IRCA results in two hypotheses to be tested:

I: IRCA reduced the supply of farm labor. This would be reflected in the data by a gradual decline in employment and/or a gradual increase in wages beginning the first quarter of 1987. These changes are expected to be permanent, leveling off over time.

II: IRCA was followed by an increase in the supply of farm labor. In this case, we expect a gradual increase in the employment data and/or a gradual decline in wages beginning the first quarter of 1987. These changes are also expected to be permanent.

NASS Farm Labor Data

Employment and wage data were provided by the National Agricultural Statistics Service (NASS) of the U.S. Department of Agriculture (USDA). These data are published in the **Farm Labor** report issued quarterly and a compilation of farm labor data reported from 1910-1990 is also available from USDA (14). Before 1975, a nonprobability mail survey was the source of farm labor information. Estimates were based on panels of volunteers who reported the number of workers on their farms and the prevailing wage rates. Since 1975, the wage and employment estimates reported in **Farm Labor** have been based on regional probability surveys. Each year the surveys collect information, pertaining to one week, every January, April, July, and October. The statistical procedures used in the current surveys provide more reliable data than previous methods. To avoid any data inconsistencies, the time series used in our analysis begins in 1975.

NASS also reports wage and employment estimates by type of worker and region. Employed workers are classified as hired, self-employed, unpaid, or service workers. However, wages are only reported for hired workers, excluding service workers. We use the hired-worker classification in our analysis to maintain consistency between the wage and employment time series data.

Data are collected in all States except Alaska. Aggregate labor estimates for the United States are computed from 18 regional estimates and both are reported each quarter. Estimates from the California and Florida surveys are reported as separate regions and survey data from the other States are grouped into 16 additional regions. Our analysis includes a U.S. aggregate model and four regional models: (1) California, (2) Florida, (3) the Pacific (Oregon and Washington), and (4) the Southern Plains (Texas and Oklahoma). The regions were chosen because of the proportionally high number of SAW applicants in these areas -- over 75 percent of the SAW applicants live in these six States.

Each time series analyzed begins in January 1975 and ends in October 1991. However, NASS cut back the labor surveys in 1981 because of budget reductions. Thus, the data series on both employment and wages contain some missing observations. The **Farm Labor** report only published estimates for January and April in 1981. Only the July surveys were conducted in 1982-83, and the July and October surveys were conducted in 1984. From 1985-88, 3 quarters of data were collected (excluding January) for most regions. In a few regions four quarters of data were collected starting in 1985 and the rest of the regional surveys were restored to 4 quarters in 1989.

Table E1. Intervention model results for farm employment, 1975-1991

Region/ parameter 1/	Estimated coefficients	Standard error	t statistic	Q statistic 2/
		Measure		
United States 3/4/				19.92
ϕ_{12}	-0.440	0.126	-3.49	
ω	0.018	0.032	0.57	
δ	-0.952	0.384	-2.48	
California 3/4/				22.11
ϕ_1	-0.343	0.114	-3.01	
ϕ_2	-0.579	0.107	-5.42	
S_1	-0.329	0.032	-10.30	
S_2	-0.224	0.042	-5.38	
S_3	0.087	0.032	2.76	
ω	0.106	0.056	1.90	
δ	-0.879	0.096	-9.11	
Florida 4/				26.63
θ_1	0.574	0.127	4.50	
θ_2	0.264	0.128	2.07	
S_1	15.985	2.773	5.77	
S_2	13.313	3.005	4.33	
S_3	-9.193	2.718	-3.38	
ω	4.150	4.749	0.87	
δ	-1.012	0.095	-10.59	
Pacific 4/				16.31
θ_1	0.695	0.096	7.25	
S_1	-43.664	3.830	-11.40	
S_2	-19.267	3.754	-5.13	
S_3	39.151	3.696	10.59	
ω	8.311	12.654	0.66	
δ	-0.172	1.653	-0.10	
Southern Plains 3/				17.66
μ	0.010	0.005	-2.01	
θ_1	0.515	0.129	3.98	
θ_2	0.261	0.130	2.01	
S_1	-0.225	0.043	-5.22	
S_2	-0.015	0.050	-0.30	
S_3	0.213	0.042	5.13	
ω	0.143	0.143	1.00	
δ	-0.213	1.053	-0.20	

1/ μ = constant and S_i = coefficient of the seasonal dummy variable, where i = 1,2,3, the first second and third quarters of the year, respectively. 2/ Value of Q-statistic based on 24 residual autocorrelations. 3/ A logarithmic transformation was made to the data because the natural log of the series displayed greater spatial homogeneity. 4/ No constant was used because it did not differ significantly from zero.

An intervention analysis of the type proposed requires that observations be equally spaced in time over the entire time series. Therefore, estimates of NASS's wage and employment values were used in the quarters when data were not collected. The method used to derive the estimates is similar to the ARIMA procedure described earlier. For details on the estimation procedure see the SAS/ETS Users Guide. There is no way of knowing how close these estimates would be to the actual values if the data had been collected by NASS. However, they conform to the trend, seasonality, and other predictable components identified in the time series models, which makes them consistent with the observed data. Adding the missing data estimates to the NASS farm labor time series provides continuous data sets from 1975 to 1991 for the United States and the four regions considered.

Table E2. Intervention model results for farm wages, 1975-1991

Region/ parameter 1/	Estimated coefficients	Standard error	t statistic	Q statistic 2/
		Measure		
United States 3/				17.46
ϕ_1	-0.397	0.122	-3.26	
ϕ_4	-0.333	0.135	-2.47	
ω	-0.025	0.035	-0.71	
δ	0.859	0.431	1.99	
California				22.04
μ	0.064	0.009	6.89	
θ_1	0.537	0.111	4.83	
S_1	0.123	0.038	3.23	
S_2	0.019	0.038	0.48	
S_3	-0.123	0.037	-3.29	
ω	-0.003	0.008	-0.41	
δ	1.214	0.178	6.81	
Florida				21.19
μ	0.050	0.008	6.05	
θ_1	0.592	0.108	5.45	
S_1	0.246	0.049	5.00	
S_2	0.107	0.045	2.39	
S_3	-0.121	0.048	-2.51	
ω	0.570	0.133	4.28	
δ	-0.903	0.041	-21.90	
Pacific				23.44
μ	0.049	0.016	3.04	
ϕ_1	-0.263	0.119	-2.21	
ϕ_2	-0.427	0.118	-3.60	
S_1	0.084	0.060	1.40	
S_2	-0.350	0.077	-4.52	
S_3	-0.707	0.059	-12.04	
ω	0.121	0.150	0.81	
δ	0.639	0.565	1.13	
Southern Plains				9.16
μ	0.047	0.008	5.64	
θ_1	0.498	0.114	4.36	
S_1	0.133	0.039	3.43	
S_2	-0.060	0.036	-1.68	
S_3	-0.250	0.038	-6.61	
ω	-0.117	0.110	-1.07	
δ	-0.897	0.169	-5.30	

1/ μ = constant and S_i = coefficient of the seasonal dummy variable, where I = 1,2,3, the first second and third quarters of the year, respectively. 2/ Value of Q-statistic based on 24 residual autocorrelations.
3/ No constant was used because it did not differ significantly from zero.

Results of the Intervention Models

The ARIMA models were developed through the iterative technique of identification, estimation, and diagnostic checking popularized by Box and Jenkins. The seasonality apparent in the quarterly series was accounted for through the use of either seasonal differencing, where $\Delta_4 Y_t = Y_t - Y_{t-4}$, or seasonal dummy variables. A test developed by Hylleberg, et al. to distinguish between these methods was applied to each series.

Tables E1 and E2 show the maximum-likelihood estimates and associated diagnostic statistics of the intervention models. The estimates of the autoregressive (ϕ_1, ϕ_2, ϕ_4, ϕ_{12}) and moving-average (θ_1 and θ_2) terms and most of the seasonal factors are statistically significant. Respective Q-statistics for each model are not statistically significant at the 95 percent level, indicating that the residuals of each model are random, and thus unpredictable (11).

The intervention models estimated show no measurable IRCA impact on farm employment or wages. The initial impact parameter, , is not statistically significant in eight out of the ten models estimated. In the two models where is significant, employment in California and wages in Florida, the rate of growth parameter, , exceeds the bounds of system stability; even though the t-statistics on are large for these series, they fail to suggest an impact. Thus, the findings provide no evidence that employer sanctions issued under IRCA resulted in a reduction of agricultural labor. Similarly, the findings do not support the hypothesis that IRCA increased the farm labor supply by stimulating unauthorized immigration.

To account for possible behavioral lags in the farm labor market, the original interventions were expanded to include different starting points. An exploratory analysis was conducted by allowing the onset of IRCA's impacts to vary sequentially from the second quarter of 1987 to the fourth quarter of 1989. Results of the exploratory analysis were consistent with the intervention models that designate the onset of IRCA's impacts as occurring in the first quarter of 1987. Even when allowing the onset of any potential adjustments in the labor market to vary from 1 (April 1987) to 11 (October 1989) quarters, we found no evidence that IRCA had a significant impact on farm employment and/or wages of the type expected under hypotheses I or II.

Since the intervention analysis did not uncover any significant impacts in either the employment or wage data, the remainder of this section will focus on a visual description of farm employment in the regions considered. Any such description is limited by the shortcomings discussed earlier. To see annual U.S. employment trends more clearly, a plot of July observations only are shown in figure E3. Without the seasonal fluctuations, a downward trend in the series is

apparent. This trend does not appear to deviate after the passage of IRCA in 1986. Similarly, the data in figure E4 do not provide any strong evidence that regional employment trends were influenced by IRCA. Thus, consistent with the intervention analysis, the plots show evidence that neither employment nor wages deviated significantly from their historical trends in the periods following IRCA.

Conclusions

Intervention analysis provided no evidence that IRCA had a significant impact on farm employment or wages. Established patterns in farm employment and wage data for both the United States and four U.S. regions did not appear to be influenced significantly by the program. We found no empirical evidence that IRCA caused farmers to adjust to a smaller workforce. At the same time, the statistical findings did not suggest that farm employment increased significantly due to a labor surplus.

While our findings show that IRCA had no effect on employment or wages for the United States or selected regions, IRCA may have had an impact on farm employment and/or wages in local areas within certain regions. The data used in this study are aggregate for the U.S. and regional labor markets and any local impacts may be overwhelmed by a lack of significant effects in the rest of the region. Thus, the results of this study may not apply to some local labor markets.

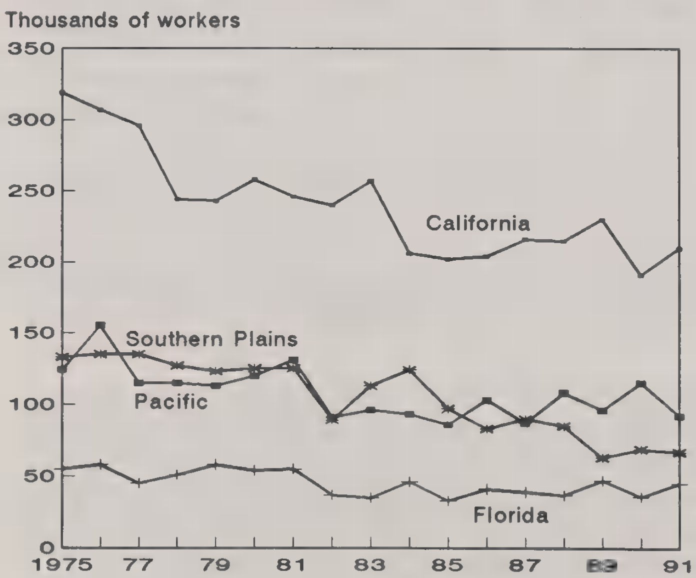
Figure E3

U.S. Farm Employment in July, 1975-1991

Excludes agricultural service workers.

Figure E4

Regional Farm Employment in July, 1975 - 91



Excludes agricultural service workers.

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